

Energy Supply

Solar and Renewable Resources Technologies

Executive Budget Summary

Mission

The Energy Efficiency and Renewable Energy (EERE) program of the Department of Energy develops and deploys clean energy technologies that contribute to a stronger economy, healthier environment and energy security for the nation.

Activities funded under the Energy and Water Development Appropriation advance a broad range of renewable electric, fuel, and related storage and power delivery technologies including Solar, Wind, Geothermal, Biomass, Hydrogen, Hydropower, Superconductivity, and Advanced Energy Storage Systems. In cost-shared partnerships with the nation's manufacturers, utilities, and states, the Department works to advance the development and deployment of technologies that benefit the entire nation. Accelerating the use of renewable energy is essential to providing the reliable, affordable and clean energy system of the future. As such, EERE supports the Department's goal of promoting reliable, competitive, and environmentally responsible energy systems that serve the needs of the public.

Strategy

EERE's strategic objectives for clean energy reflect the Administration's interest in the benefits that energy research and development can deliver to all Americans. The use of advanced clean energy technologies reduces harmful air pollutants and greenhouse gas emissions and lowers both energy costs and dependence on petroleum for fuel and feedstocks.

In light of these benefits, the Administration requests substantial support for the Department's clean energy efforts. To meet the Department's objectives, EERE is integrating the efforts of its five program offices, which have developed and deployed technologies for the power, transportation, industrial, buildings, and Federal sectors during the past two decades. This integration is demonstrated through targeted cross-cutting initiatives, such as:

Presidential Initiatives

- # Bioenergy/Bioproducts
- # Climate Change Technology
- # International Clean Energy
- # Million Solar Roofs

Secretarial Initiatives

- # Power Outage Prevention. (short term)
- # Energy Grid Reliability (long term)
- # Energy Smart Schools
- # Lighting and Appliance Standards
- # Natural Gas
- # Wind Powering America
- # GeoPowering the West

Energy Resources Goals - EERE programs address the goals of the Department's Energy Resources Business Line:

- # Reduce the vulnerability of the U.S. economy to disruptions in energy supplies.
- # Ensure that a competitive electricity generation industry is in place that can deliver reliable and affordable supplies with reduced environmental impact.
- # Reduce energy-related environmental impacts.
- # Support U.S. energy, environmental, and economic interests in global markets.
- # Carry out information collection, analysis, and research that will facilitate development of informed positions on long-term energy supply and use alternatives.

In supporting the achievement of these goals, EERE programs are responding to challenges and opportunities that have a major impact on the nation's economy and environmental quality:

National Security

The Energy Information Administration projects that by 2015, U.S. consumption of oil will increase more than 20 percent to more than 24 million barrels per day (63 percent will be imported — a higher ratio than at the time of the oil shocks of the 1970s). Demand for petroleum in non-industrialized countries is projected to almost double by 2020, and Organization of Petroleum Exporting Countries (OPEC) nations are expected to supply over half of world petroleum production, as compared to 40 percent today. Given historical precedents and future oil market trends, the United States has a critical interest in diminishing the nation's reliance on foreign oil. EERE programs support development and deployment of renewable energy technologies that reduce reliance on oil as an energy source, to the benefit of national security and reduction of the U.S. trade deficit.

Electricity Restructuring

The United States consumes more than \$200 billion worth of electricity each year, more electricity than Western Europe and Japan combined. The Energy Information Administration projects that approximately 235,000 megawatts of new power generation additions will be required by 2015 (current capacity is about 750,000 megawatts). Electricity generation accounts for 38 percent of annual U.S. primary energy consumption and a similar share of U.S. greenhouse gas emissions, and in some areas adversely impacts local and regional air quality.

The electric power industry is in the midst of restructuring to increase competition and consumer choice. However, a new competitive electric marketplace will require the Nation's utility infrastructure to operate in ways for which it was not originally designed, and may not include sufficient incentives for developing and deploying more advanced technology. New technologies will be required to ensure that adequate, reliable, reasonably-priced, and environmentally sensitive electricity supplies are available during and after the restructuring process.

The reliable delivery of electric services in competitive, restructured electric markets is being addressed by two Secretarial Initiatives: Power Outage Prevention and Energy Grid Reliability. The Power Outage Prevention Initiative is a near term effort to address significant power outages and other system disturbances, that frequently occur during summer peak loads, and to recommend federal actions to avoid these power outages and disturbances in the future. The Energy Grid Reliability Initiative focuses on longer term technology solutions to ensure the reliable delivery of electric services in competitive, restructured electric markets. The Transmission Reliability program contributes to both initiatives.

EERE is working with utilities, industry, states, and consumers to ensure that electricity restructuring results in a competitive and effective electric power industry. Power market restructuring presents an opportunity to reduce energy costs, advance the use of energy efficient and renewable energy technologies, and provide affordable and reliable services with reduced environmental impacts.

Environmental Quality

Air pollution, particularly in urban centers, ranks high among the nation's most pressing environmental concerns. EERE renewable energy technologies mitigate and minimize environmental costs associated with energy use and offer a cleaner, environmentally responsible option for generating power.

The FY 2001 budget request for EERE programs is a major element of the President's Climate Change Technology Initiative, a multi-billion dollar investment over five years to reduce greenhouse gas emissions. In 1997, a major study conducted by five national laboratories documented the critical role that development and deployment of renewable energy technologies can play in reducing greenhouse gases. Given the cost savings associated with these technologies, the study noted that aggressive investment in energy R&D and deployment could lead to significant emissions reductions without raising the nation's energy bill. The President's budget request for EERE programs also includes activities to enable the private sector to achieve emissions reductions overseas – at potentially the lowest cost – and to respond to direction to encourage meaningful participation by developing countries in a global effort to address this issue.

Economic Competitiveness

The Department's clean energy R&D advances U.S. economic interests by maintaining America's technological expertise and competitive advantage in the global market. International markets represent a multi-billion dollar opportunity for U.S. clean energy technology providers. In partnership with industry, national laboratories, and universities, EERE's research and development programs are laying the foundation for a more sustainable energy future. EERE also sponsors international programs to promote U.S. clean energy technologies and services in international markets.

Energy prices, particularly for oil, are now relatively low (in real terms), and electric utility restructuring is expected to support this general trend by subjecting the pricing of electricity to the discipline of market forces. If energy prices remain low for the near future as many project, private sector investments in

energy R&D could be reduced and introduction of new, commercial-scale technologies into the market delayed or deferred. But, R&D and adoption of new technologies is a long-term process. The size and complexity of the U.S. energy systems, and the large capital requirements of many energy investments are such that the transition to new energy sources and fuels has historically taken from several decades, as did the development of our current power sources. A substantial period of R&D, in some cases decades, may be needed to ensure that robust technological and energy options are available when the need arrives.

Crosscutting Initiatives

EERE strongly supports Department of Energy initiatives that address new opportunities in bioenergy, international energy markets, electricity market restructuring, energy savings in schools, and the reliability of the electricity grid. Many of these efforts extend across organizational boundaries and require extensive cooperation among EERE sectors offices, Departmental elements and other Federal agencies. EERE-supported advances in fuel cells, distributed power, cofiring, advanced materials, biomass and agricultural processes, and other areas of crosscutting research now allow EERE programs to collaborate on accelerating the development of energy technologies that apply to all sectors of the economy.

Bioenergy/Bioproductions

In August 1999, the Administration issued an Executive Order on bioenergy and bioproducts, launching a national Bioenergy/Bioproductions Initiative designed to speed the development of biomass as an environmentally friendly, renewable energy source. The Bioenergy/Bioproductions Initiative is a national partnership to develop an integrated industry that produces power, fuels and chemicals from crops, trees, and agricultural wastes—the nation’s abundant biomass resources. Building on existing efforts, the Bioenergy/Bioproductions Initiative will create new and economically viable options for farmers, foresters, fuels producers, chemical manufacturers, wood products companies, electricity producers and consumers to use and profit from biomass commodities, products, and services. By making biomass a resource that competes with fossil energy in the marketplace, the Bioenergy/Bioproductions Initiative will help grow the U.S. economy, strengthen energy security, protect the environment, reduce greenhouse gas emissions, and revitalize rural America.

International Clean Energy

Contributing to international efforts, the Department of Energy facilitates deployment of renewable technologies in developing countries and other nations in support of U.S. national interests and policies. The strategic focus of the EERE international activities is to address emerging global environmental issues, to promote trade and market development, and to ensure energy and environmental security. The June 1999 report issued by the President’s Council of Advisors for Science and Technology (PCAST), *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation*, stresses the need for greater federal coordination and funding of international activities to promote greater use of renewable and efficient U.S. energy technologies in global markets. The report found that international cooperation on energy innovation lowers the cost and increases the pace of U.S. energy innovation. It concluded that the economic, environmental and security impacts of global energy production and use warrants U.S. government support for such cooperation. PCAST has recommended to the President that existing Federal activities in support of international cooperation on energy innovation be increased.

Distributed Power

EERE is coordinating program efforts to advance small-scale, on-site power generation as an alternative to centralized baseload power generation. This “distributed generation”—based on fuel cells, gas turbines, hydrogen technologies, photovoltaics, concentrating solar power, or hybrid fossil/renewable power systems—can greatly reduce energy use and carbon dioxide emissions. EERE has launched the Combined Heat and Power Initiative to develop and deploy systems for industry and buildings that produce both electricity and thermal energy from a single power source. In addition, EERE is supporting demonstrations of residential and building-sized hydrogen/natural gas fuel cells for off-grid applications.

Transmission Reliability (Energy Grid Reliability)

EERE’s transmission reliability program is designed to ensure an efficient, reliable power delivery system in the U.S. during the electricity industry’s transition to competitive markets. Recent summer and winter power outages affecting all regions of the nation highlight the need for aggressive efforts on electricity reliability. EERE is developing advanced technologies for reliable and cost-efficient power delivery, with an emphasis on the integration of distributed generation resources. These technologies will likely include real time controls for reliable, efficient operation of the nation’s power system under both normal and emergency conditions.

Electricity Restructuring

In a parallel effort, the EERE Electricity Restructuring initiative provides technical assessments to Federal and State officials on restructuring issues related to energy efficiency and renewable energy. These assessments assist decision makers in developing and coordinating utility restructuring legislation and regulations to include suitable policy and market mechanisms for renewable energy and energy efficiency.

EnergySmart Schools

In FY 1999, the Secretary of Energy launched the EnergySmart Schools partnership to bring both renewable energy technologies and energy efficiency improvements to the nation’s new and existing schools. EnergySmart Schools brings together public and private sector resources to reduce energy bills and improve the learning environment in schools by redirecting the savings to our children’s education. Schools can potentially save up to \$1.5 billion in energy costs, and over 3.6 million metric tons of carbon dioxide emissions by 2010. The EnergySmart Schools Initiative uses existing programs, including the State Energy Programs, Rebuild America, Clean Cities, Energy Star and the President’s Million Solar Roofs Initiative, along with partners’ efforts, to provide technical assistance, an information clearinghouse, technology demonstrations, guidance in financing mechanisms and design, and education in energy awareness to school districts around the country. With the help of this partnership, schools across the country are not only reducing their energy costs but also realizing educational and other benefits from incorporating clean energy technologies, including solar energy systems and geothermal heating and cooling systems in their schools.

Million Solar Roofs

EE sector programs are combining efforts to support the President’s Million Solar Roofs Initiative, facilitating the installation of photovoltaic and solar hot water systems on one million buildings across the nation by 2010. Million Solar Roofs is implemented by the EERE Office of Power Technologies, in cooperation with EERE Office of Buildings, State and Community Programs and the Federal Energy Management Program.

The Department's energy R&D programs are conducted in partnership with the National Laboratories, private sector companies and organizations, universities, other Federal agencies, and state and local entities. EERE works with States to deploy energy technologies by collaborating with state energy offices and local communities to showcase technology applications and to provide technical assistance. States work closely with EERE on research, development and deployment of energy technologies under Memorandum of Understanding agreements that emphasize State participation in the identification of research needs and in the planning and performance of joint research.

Major Changes

Managing for Results - Continuous management improvement is central to the effective and efficient accomplishment of the mission of the Office of Energy Efficiency and Renewable Energy (EERE). Specific reforms that have been accomplished in the past year as well as new initiatives are summarized below:

- # **Strategic Planning and Technology Roadmaps** - Consistent with the Government Performance and Results Act, EERE has developed a new strategic plan. The strategic plan sharpens the Office's focus on business strategies that will improve the efficiency and effectiveness of operations.
- # **Increasing Competition** - In FY 1999, EERE substantially increased its competitive funding of grants and cooperative agreements. EERE awarded more than 90 percent of funds for new discretionary financial assistance awards on a competitive basis in FY 1999 compared with 24% in FY 1996. EERE intends to continue to sharpen its competitive strategies in FY 2001.

Much of the increased competition was carried out through the issuance of two broad-based competitive solicitations which provided information dissemination services and innovative ideas for EERE. The first solicitation involved information dissemination, outreach, training, and related technical analysis and technical assistance activities. This solicitation, which had a total dollar value of approximately \$15 million in FY 1999 funding, was designed to increase energy efficiency and the use of renewable energy and alternative fuels and involved activities which often had been awarded by individual EERE programs on a noncompetitive basis in the past. Following a rigorous merit review process, EERE awarded approximately 140 agreements out of a total of more than 530 applications. The second broad-based solicitation involved research, development, and demonstration (RD&D) of energy efficiency and renewable energy technologies. EERE awarded approximately 40 grants and cooperative agreements under this solicitation, with a value of approximately \$7 million.

- # **Refining Merit Review Procedures** - In FY 1999, EERE also refined its objective merit review processes through new regulations and additional guidance and training, and these guidance and training efforts will continue in FY 2000. In conjunction with the two broad-based solicitations, more than 100 people involved with the selection process received training on merit review and competitive selection procedures. In addition, during the summer of 1999, approximately 75 EERE management and staff attended comprehensive training sessions on financial assistance policies and procedures. The review of proposals by independent reviewers helped assure the selection of the highest quality projects.

- # **Managing Smarter** - In FY 1999, EERE initiated a number of actions to improve its overall management processes. The Assistant Secretary appointed a Management Improvement Team and contracted with the National Academy of Public Administration to review EERE management practices. In addition, he established a Chief Operating Officer in EERE who directs the new Office of Planning, Budget, and Management and is responsible for corporate management functions. This new office has made significant progress in implementing business management systems to assist program managers in tracking technical milestones, costs, and schedules and promote increased accountability. In recent months, EERE also has finalized its Strategic Management System. The Strategic Management System strengthens the operational planning process, including improvements in budget formulation, budget execution, and procurement planning by FY 2002.
- # **Leveraging Federal Investments by Expanding Partnerships with Federal, State, and Other Entities** - EERE is strengthening its partnerships with other government entities and the private sector to better leverage the Federal investment in RD&D and to facilitate the deployment of new technologies. For example, EERE has made substantial progress on an initiative to pursue joint efforts with State organizations pursuing energy technology R&D. In 1999, the Department completed a landmark model agreement with the California Energy Commission which will greatly facilitate research activities between State research organizations and DOE's national laboratories. With Congressional support, EERE also developed a mechanism to support joint work with the States in several priority R&D areas.

Site Funding and Federal and Contractor Staffing Profiles

In support of its priorities, EERE submits the following FY 2001 Congressional Request. The tables below cover both the Energy Supply and Energy Conservation Appropriations.

Energy Efficiency and Renewable Energy Programs FY 2001 Congressional Budget Request (in thousands of dollars)				
Program	FY 1999	FY 2000 Current Appropriation	FY 2001 Request	Change FY 2000 vs. FY 2001
Solar and Renewable Resources Technologies	332,319	310,116	409,500	99,384
Building Technology, State and Community Programs	261,135	283,998	339,759	55,761
Federal Energy Management Program	23,764	23,918	29,468	5,550
Industrial Technologies	162,775	175,200	184,026	8,826
Transportation Technologies	198,665	232,760	250,870	18,110
Policy and Management	38,039	42,866	46,377	3,511
PODRA and Prior Year Balances	(66,384)	(821)	0	(821)
Transfer from Biomass Energy Development ^a	0	(25,000)	(2,000)	23,000
Total Budget Authority ^b	950,313	1,068,037	1,260,000	191,963

^aNon-add for Energy Conservation under OMB scoring rules. The transaction is applied against the U.S. Treasury, where the account resides.

^bTotal Budget Authority figures take into account prior year balances and receipts associated with the Petroleum Overcharge Distribution and Restitution Act (PODRA), and Contractor Travel Savings.

Federal Staffing at Field and Headquarters (FTEs)			
Field and Headquarters Sites	FY 1999	FY 2000	FY 2001
Solar and Renewable Resources Technologies			
Golden Field Office	16	22	22
Idaho Operations Office	1	1	1
Headquarters	<u>90</u>	<u>98</u>	<u>98</u>
Subtotal FTEs, Solar and Renewable Resources Technologies	107	121	121
Energy Efficiency Programs			
Building Technology, State and Community Sector			
Headquarters	73	81	81
Federal Energy Management Program			
Headquarters	21	30	32
Transportation			
Headquarters	55	62	62
Oak Ridge Operations Office	<u>1</u>	<u>1</u>	<u>1</u>
Subtotal	56	63	63
Industry			
Headquarters	56	63	63
Chicago Operations Office	6	6	6
Idaho Operations Office	<u>4</u>	<u>4</u>	<u>4</u>
Subtotal	66	73	73
Policy and Management			
Headquarters	64	62	60
Golden Field Office	29	30	30
Atlanta Regional Office	20	25	25
Boston Regional Office	12	18	18
Chicago Regional Office	16	20	20
Denver Regional Office	22	27	27
Philadelphia Regional Office	17	19	19
Seattle Regional Office	<u>19</u>	<u>22</u>	<u>22</u>
Subtotal	<u>199</u>	<u>223</u>	<u>221</u>
Subtotal FTEs, Energy Efficiency Programs	415	470	470
Total FTEs, Energy Efficiency and Renewable Energy	522	591	591

Program Funding Detail

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Current Appropriation	FY 2001 Request	Funding Change
Solar and Renewable Resources Technologies				
Solar Building Technology Research				
Space Conditioning and Water Heating	3,556	1,968	4,500	2,532
Photovoltaic Energy Systems				
Fundamental Research	10,761	14,221	20,300	6,079
Advanced Materials and Devices	25,836	27,000	27,000	0
Technology Development	33,964	24,691	34,700	10,009
Total, Photovoltaic Energy Systems	70,561	65,912	82,000	16,088
Concentrating Solar Power				
Distributed Power System Development	5,300	5,155	4,300	-855
Dispatchable Power System Development	5,970	5,956	5,200	-756
Advanced Component and System Research ...	4,781	4,057	5,500	1,443
Strategic Alliances & Market Awareness	740	0	0	0
Total, Concentrating Solar Power	16,791	15,168	15,000	-168
Biomass/Biofuels Energy Systems				
Power Systems				
Thermochemical Conversion	1,550	1,700	5,000	3,300
System Development	25,716	23,035	26,400	3,365
Feedstock Production	2,300	3,100	4,000	900
Regional Biomass Energy Program	1,250	1,000	1,600	600
Bioenergy/Bioproducts Initiative	0	3,000	11,000	8,000
Total, Power Systems	30,816	31,835	48,000	16,165
Transportation				
Ethanol Production	35,436	30,142	38,441	8,299
Renewable Diesel Alternatives	750	750	1,000	250
Feedstock Production	2,800	3,000	4,500	1,500
Regional Biomass Energy Program	2,250	2,000	3,500	1,500
Integrated Bioenergy Research and Development	0	3,000	7,000	4,000
Total, Transportation	41,236	38,892	54,441	15,549
Total, Biomass/Biofuels Energy Systems	72,052	70,727	102,441	31,714
Wind Energy Systems				
Applied Research	10,700	13,500	15,000	1,500
Turbine Research	15,815	12,500	14,500	2,000
Cooperative Research & Testing	7,561	6,481	21,000	14,519
Total, Wind Energy Systems	34,076	32,481	50,500	18,019
Renewable Energy Production Incentive Program	4,000	1,500	4,000	2,500

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Current Appropriation	FY 2001 Request	Funding Change
Solar Program Support				
Electricity Restructuring	0	984	2,500	1,516
Competitive Solicitation	0	3,952	4,000	48
Total, Solar Program Support	0	4,936	6,500	1,564
International Renewable Energy Program				
USJI	6,272	3,819	6,000	2,181
International Clean Energy Initiative	0	0	5,500	5,500
Total, International Renewable Energy Program	6,272	3,819	11,500	7,681
National Renewable Energy Laboratory	3,900	1,100	1,900	800
Geothermal				
Geoscience and Supporting Technologies	10,866	12,050	11,000	-1,050
Drilling Research	4,934	5,500	5,500	0
Energy Systems Research and Testing	5,930	6,071	10,500	4,429
Geothermal Heat Pumps	6,420	0	0	0
Total, Geothermal	28,150	23,621	27,000	3,379
Hydrogen Research	21,976	24,587	23,000	-1,587
Hydropower	3,210	4,921	5,000	79
Renewable Indian Energy Resources	4,779	3,864	5,000	1,136
Electric Energy Systems and Storage				
Transmission Reliability	4,251	2,955	11,000	8,045
High Temperature Superconducting R&D	32,100	31,408	32,000	592
Energy Storage Systems	4,445	3,429	5,000	1,571
Climate Challenge	100	0	0	0
Total, Electric Energy Systems and Storage	40,896	37,792	48,000	10,208
Federal Buildings/Remote Power Initiative	4,000	0	0	0
Program Direction				
Golden Field Office	1,905	2,155	2,779	624
Idaho Operations Office	86	95	100	5
Headquarters	16,109	15,470	15,280	-190
Total, Program Direction	18,100	17,720	18,159	439
Departmental Energy Management Program	0	0	5,000	5,000
Subtotal, Solar and Renewable Resources Technologies	332,319	310,116	409,500	99,384
Use of Prior Year Balances	-1,001	0	0	0
Total, Solar and Renewable Resources Technologies	331,318	310,116	409,500	99,384

Solar and Renewable Resources Technologies

Program Mission

The mission of the Solar and Renewable Resources Technologies program is to lead the national effort to develop and support clean competitive, reliable renewable energy and power delivery technologies for the 21st century. Within the Office of Energy Efficiency and Renewable Energy (EERE), the program supports research and development of clean, reliable renewable energy technologies and cutting edge power delivery technologies that will enable the reliable delivery of electric services for consumer use in competitive, restructured electric markets.

The Solar and Renewable Resources Technologies program contributes to national energy security, enhances U.S. economic competitiveness, and reduces the environmental impacts of energy-related activities. The program provides additional clean-power options for a restructured electricity supply industry and clean liquid biofuels for the transportation sector. The EERE Office of Power Technologies implements most of the program activities, while the EERE Office of Transportation Technologies administers the Biofuels portion of the Biomass/Biofuels Energy Systems Program.

Program Goals and Objectives

The goal of the Program is to improve the Nation's overall economic strength, energy security, and environmental health through the development of clean, competitive reliable power technologies for the 21st century.

The electric power sector is the largest direct consumer of energy in the United States. It used 36 percent of all primary energy consumed in the country in 1997, providing power worth approximately \$200 billion annually to fuel a myriad of essential functions in our homes, businesses, and industries. Most energy projections show the United States requiring an increase of 100,000 to 200,000 megawatts of additional power generation capacity between now and the year 2010.

About 68 percent of the electric energy generated in the United States is fueled by coal, natural gas, and oil; the balance is provided by nuclear (20 percent), hydroelectric, and renewable technologies. Due to the reliance on fossil fuels, power generation currently contributes to the pollutants and greenhouse gas emissions in the United States, at a time when world concern continues to grow regarding climate change. Meeting the projected increase in demand for electric power without compromising the Nation's environmental standards is therefore essential to sustaining the Nation's economic growth while at the same time protecting human health and the environment.

Many power producers, either in response to public pressure or State and Federal regulatory trends, are seeking to diversify their choices and add renewable energy resources to their fuel mix. Environmental concerns, ample supplies of natural gas (the cleanest fossil fuel), current and potential constraints of large system power transmission and distribution, and technological advances are causing distributed and hybrid systems and technologies such as combined heat and power systems, gas turbines, fuel cells, photovoltaics, wind turbines, solar, geothermal, and biomass systems to gradually augment and sometimes to replace conventional, large-scale generating technologies.

Regulated utilities have traditionally invested in power generation R&D. However, the U.S. electric power industry is restructuring in response to changes in State and Federal regulations requiring increased competition in the industry. In response to increased competitive pressures, utilities and other companies that traditionally have invested in research have reduced or eliminated their R&D budgets.

The principal objective for the Solar and Renewable Resources Technologies program is to invest in renewable energy technologies R&D focused on core technology needs. This R&D provides the technological advances needed to develop competitive new energy systems and create the basis for industry investment in product development. Areas addressed include materials and component improvement, conversion efficiency, system integration, system control, and evaluation of component lifetime. While such R&D is necessary, it must be complemented with evaluation of field system performance. User acceptance and industry commercialization investment requires confidence in the day-to-day performance, operating cost, system reliability, and operating lifetime of renewable energy. The program's activities include prototype evaluation and system field tests where appropriate, to establish a basis for predicting operation and maintenance costs.

A similar objective exists for the energy delivery programs, which include the Electric Energy Systems and Storage research and development programs and the Hydrogen program. The transition to competitive, restructured electric markets coupled with growing consumer demand for electricity and constraints in the Nation's transmission and distribution systems requires the development of an integrated set of advanced power delivery technologies to enable the reliable delivery of electric services for consumer use. Overcoming regulatory, technical, and institutional barriers to distributed power are addressed to relieve stress on the Nation's transmission systems. The development of lower cost, high performance power electronic controllers with advanced energy storage systems as part of the needed transition to real-time systems control are addressed to provide improved power quality and additional operational capacity within the existing transmission and distribution infrastructure. The development of high temperature superconducting power equipment is addressed to significantly reduce losses in the generation, delivery, and end-use of electricity and to relieve power delivery system constraints, particularly in urban areas. Lower cost and higher performance Hydrogen production and storage technologies are addressed that can integrate into any point on the Nation's electric and natural gas delivery systems. Program success depends on industry's ultimate commercialization of the program's technologies under development, partnership with industry is essential. These partnerships include industry co-investment at increasing levels as technologies near the pre-commercialization stage.

Additionally, the program utilizes the talents found at the National Laboratories and within the state, university, and other research organizations across the United States in order to achieve its R&D objectives. This not only helps us to accomplish our R&D mission, but the States are also encouraged to share "lessons learned" through their own peer network activities. Similarly, we also partner with a number of universities across the country to conduct both fundamental and applied R&D. Whenever possible, we encourage our partners to provide viable prototype power technology systems to schools and other educational facilities so that they may continue to receive the benefits of these clean reliable power systems once our R&D work is done.

Specific program objectives include:

- # **Triple the installed U.S. capacity of non-hydroelectric electric renewables by 2010 (relative to a 1996 level of 6,500 megawatts of installed capacity) and maintain the viability of hydropower as an important renewable energy resource** - through performance improvements, such as advances in conversion technology, and reductions in capital costs.
- # **Overcome barriers to distributed power to a 20 percent market penetration of new generation capacity by 2010** - facilitating the implementation of national standards for interconnecting distributed power with the grid will be a key activity.
- # **Maintain the present high reliability of the Nation's transmission and distribution systems during a period of increased consumer demands for electricity and constraints on siting and building new transmission and distribution systems** - the Electric Energy Systems and Storage research and development programs provide an integrated approach for the electricity component of the Secretary's Energy Grid Reliability Initiative.
- # **Launch a cellulosic ethanol industry** - Based on technology advancements, at least three ethanol production facilities using agricultural and/or municipal solid wastes will be operational or under construction by 2004, and another demonstration at a commercial facility be conducted by 2005 using an energy crop or closely related biomass.

Attainment of these objectives will contribute to Departmental strategic objectives as stated in the Department of Energy Strategic Plan of September 1997. These strategic objectives are to reduce the vulnerability of the U.S. economy to disruptions in energy supplies; to ensure adequate and affordable energy supplies in a competitive marketplace while improving environmental quality; to increase the efficiency and productivity of energy use; and to support U.S. energy and economic competitiveness in global markets.

The table below reflects projected aggregated benefits to the nation resulting from the Solar and Renewable Technologies program investments in technology advancements. Primary Energy Displaced refers to fossil fuels not consumed because electricity production from renewable energy sources will have displaced them or because energy has been saved through the use of advanced system technologies.

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads).	0.3-0.6	0.9-1.8	2.5-4.3
Energy Savings (\$ Billions).	1.2-2.2	3.3-5.0	6.5-7.5
Carbon Displaced Millions Metric Tons Carbon Equivalent (MMTCE)	2.7-12.1	15.3-35.5	45.1-88.3
Oil Displacement (Million of Barrels per Day).	0.01-0.03	0.1-0.1	0.2-0.3

Note: The program benefit ranges are developed through an impact analysis process undertaken annually by the Office of Energy Efficiency and Renewable Energy (EERE). EERE analyzes the impacts its programs will have on energy savings, cost savings, and carbon reduction if all program goals are met. These estimates are externally reviewed by Arthur D. Little. An integrated analysis model run by an external contractor controls for interaction effects. The integrated analysis model accounts for inter- and intra-sector double counting as well as market trends, including reductions in new electricity generation created by reduced demand.

As a comparison, estimated energy displaced in 2020 would be equal to today's electricity consumption of the five-state region comprised of Indiana, Illinois, Ohio, Michigan, and Wisconsin.

Investments in research and development of renewable energy technology are essentially investments in renewable energy reserves -- in the same sense that significant oil or coal reserves add a measure of energy security for the nation. Technological advances often make renewable energy systems economically competitive, and while these renewable technologies may not immediately enter the marketplace, they nevertheless become national assets. Unlike fossil fuel reserves, these renewable technology reserves will not be depleted.

Performance Measures

At the level of resources proposed in this budget request, significant progress is anticipated throughout the next five-year period. Demonstrative indicators of such progress in Renewable Energy and Power Delivery Technologies will be:

FY 2001- 2006 Performance Measures

Photovoltaic Energy Systems

- # The direct manufacturing cost of photovoltaic modules will be reduced from the current average cost of \$2.50/watt to \$1.50/watt, a 40% decrease.

Concentrating Solar Power Program

- # Dispatchable concentrating solar power systems will be capable of producing power at \$0.06 to \$0.08KWh.

Wind Energy Systems

- # Wind turbines capable of providing electricity at 2.5 cents per kilowatt-hour in good (15 mph) wind regions will be introduced commercially.

Biomass/Biofuels Energy Systems - Transportation

- # A three-fold improvement from 1998 levels of cellulase enzyme activity for converting cellulosic biomass to ethanol will be demonstrated, resulting in a 200% reduction in production costs.

Geothermal

- # Flash and binary power plant capital costs are reduced below \$1,400/kW and \$2000/kW respectively, a decrease of about 25% since the late 1980s.

Hydrogen

- # Develop and field validate advanced reformers that will reduce the cost of hydrogen production by 25 to 35 percent.

Electric Energy Systems and Storage

- # **High Temperature Superconducting R&D** - Testing will be in progress on a 5000 horsepower superconducting motor with half the losses of a comparable motor today. (In the United States, two-thirds of today's electricity is consumed by operating motors.)
- # **Energy Storage Systems** - Tests of an advanced battery storage systems requiring a projected 20% less square footage and with a 20% longer life than today's systems will be underway at a user site. (System space requirements are a critical factor in many customer evaluations, and system lifetime is a major factor in life cycle cost.)
- # **Transmission Reliability** - In cooperation with transmission system operators, develop, test and evaluate prototype models for monitoring and analysis of reactive power, for monitoring of the delivery of ancillary services, and for the application of wide area real time measurements.
- # **Distributed Power** - Support accelerated development of uniform national utility interconnection standards for distributed generation and storage technologies.

Significant Accomplishments and Program Shifts

Photovoltaic Energy Systems

- # Achieved an increase in U.S. photovoltaic module production output of 14 megawatts in 1997, in comparison to 1996 output.

Concentrating Solar Power Program

- # Achieved 153 hours of continuous power generation at the Solar Two power tower, which uses molten salt as heat transfer energy source system.

Biomass/Biofuels Energy Systems - BioPower Systems

- # Completed operational testing of the Vermont indirect biomass gasifier and produced clean biogas.
- # Completed engineering design for Minnesota Gasification Project for a power plant for gasification of alfalfa stems.

Biomass/Biopower Energy Systems - Transportation

- # Established partnership with the timber industry, United States Forest Service, and local communities to evaluate environmental effects of forest watershed management when forest thinnings are harvested enhancing the suppression of forest fires and using these thinnings to produce ethanol, electricity, and bio-products.

Wind Energy Systems

- # Established Underwriters Laboratories as the first U.S.-based wind turbine certification agent with technical support from the National Wind Technology Center.

Geothermal

- # Demonstrated the use of slimhole drilling for geothermal exploration, thereby reducing exploration drilling costs by 30-50% relative to 1995 technology.

Hydropower

- # Completed conceptual design for advanced “fish friendly” hydroturbine.
- # Field test higher performance reformers to validate conversion efficiencies and emissions.

Electric Energy Systems and Storage

- # The research and development efforts of the Electric Energy Systems and Storage programs are being integrated to provide a coordinated approach for the electricity component of the Secretary’s Energy Grid Reliability Initiative. Collectively, these programs are focused on the development of advanced power system technologies which will enable the reliable delivery of electric services for consumer use in competitive, restructured electric markets.
- # **Transmission Reliability** - Using the initial assessments and evaluations conducted under this program, there will be a significant shift to the development of advanced technologies which will enable real-time systems control of electric transmission and distribution systems. These advanced technologies will provide real-time information and control for additional delivery system capacity, security and reliability under competitive markets. They will also provide the flexibility to successfully integrate and reliably operate delivery systems with large amounts of distributed power.
- # **High Temperature Superconducting R&D** - Achieved high temperature superconductor with current carrying capability of 1,000,000 amperes per square centimeter in laboratory tests, over 1,000 times more capacity than copper wire.
- # **Energy Storage Systems** - Completed assembly of first transportable energy storage system; tested the 1 MW battery at a utility site, and began performance evaluation at an industrial site.

Funding Profile

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Original Appropriation	FY 2000 Adjustments	FY 2000 Current Appropriation	FY 2001 Request
Solar and Renewable Resources Technologies					
Solar Building Technology Research	3,556	2,000	-32	1,968	4,500
Photovoltaic Energy Systems	70,561	67,000	-1,088	65,912	82,000
Concentrating Solar Power	16,791	15,410	-242	15,168	15,000
Biomass/Biofuels Energy Systems	72,052	72,000	-1,273	70,727	102,441
Wind Energy Systems	34,076	33,000	-519	32,481	50,500
Renewable Energy Production Incentive Program	4,000	1,500	0	1,500	4,000
Solar Program Support	0	5,000	-64	4,936	6,500
International Renewable Energy Program	6,272	4,000	-181	3,819	11,500
National Renewable Energy Laboratory	3,900	1,100	0	1,100	1,900
Geothermal	28,150	24,000	-379	23,621	27,000
Hydrogen Research and Development.	21,976	25,000	-413	24,587	23,000
Hydropower Development	3,210	5,000	-79	4,921	5,000
Renewable Indian Energy Resources	4,779	4,000	-136	3,864	5,000
Electric Energy Systems and Storage	40,896	38,410	-618	37,792	48,000
Federal Buildings/Remote Power Initiative	4,000	0	0	0	0
Program Direction	18,100	17,720	0	17,720	18,159
Departmental Energy Management Program	0	0	0	0	5,000
Subtotal, Solar and Renewable Resources Technologies	332,319	315,140	-5,024	310,116	409,500
Use of prior year balances (EE). ..	-1,001	0	0	0	0
Total, Solar and Renewable Resources Technologies	331,318	315,140	-5,024 ^a	310,116	409,500

^aIncludes adjustments for rescissions, M&O contractor travel, M&O contractors at headquarter, and general reduction.

Public Law Authorization:

P.L. 94-163, "Energy Policy and Conservation Act" (ECPA) (1975)
P.L. 94-385, "Energy Conservation and Product Act" (ECPA) (1976)
P.L. 95-91, "Department of Energy Organization Act" (1997)
P.L. 95-618, "Energy Tax Act of 1978"
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Powerplant and Industrial fuel Use Act of 1978"
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act of 1987"
P.L. 100-615, "Federal Energy Management Improvement Act of 1988"
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989"
P.L. 101-549, "Clean Air Act Amendments of 1990"
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990"

Climate Change Technology Initiative (CCTI)

Departmental Crosscut

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Current Appropriation	FY 2001 Request	\$ Change	% Change
Energy & Water Development					
Energy Supply					
Solar and Renewable	332,319	310,116	409,500	99,384	32.0%
Nuclear Energy	0	4,976	5,000	24	0.5%
Subtotal, Energy Supply	332,319	315,092	414,500	99,408	31.5%
Science	13,135	33,000	36,700	3,700	11.2%
Total, Energy & Water	345,454	348,092	451,200	103,108	29.6%
Interior and Related Agencies					
Energy Conservation R&D	518,378	590,242	659,500	69,258	11.7%
Fossil Energy R&D	23,880	38,438	56,100	17,662	45.9%
Energy Information Administration	2,500	3,000	2,500	-500	-16.7%
Total, Interior and Related Agencies	544,758	631,680	718,100	86,420	13.7%
Total, DOE Climate Change Technology Initiative	890,212	979,772	1,169,300	189,528	19.3%

Funding by Site

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	6,810	6,686	6,953	267	4.0%
National Renewable Energy Laboratory . . .	129,935	123,319	169,545	46,226	37.5%
Sandia National Laboratory	39,210	31,374	30,499	-875	-2.8%
Golden Field Office	56,588	53,377	70,036	16,659	31.2%
Atlanta Support Office	805	791	1,114	323	40.8%
Boston Support Office	950	941	1,347	406	43.1%
Chicago Support Office	640	621	865	244	39.3%
Denver Support Office	1,180	1,081	1,404	323	29.9%
Philadelphia Support Office	203	190	236	46	24.2%
Seattle Support Office	1,170	1,121	1,565	444	39.6%
Albuquerque Operations Office	1,345	1,231	1,549	318	25.8%
Total, Albuquerque Operations Office	238,836	220,732	285,113	64,381	29.2%
Chicago Operations Office					
Argonne National Laboratory	5,103	4,956	5,403	447	9.0%
Brookhaven National Laboratory	2,212	1,966	2,202	236	12.0%
Chicago Operations Office	2,200	2,113	6,552	4,439	210.1%
Total, Chicago Operations Office	9,515	9,035	14,157	5,122	56.7%
Idaho Operations Office					
Idaho National Engineering and Environmental Laboratory	0	0	0	0	0.0%
Idaho Operations Office	22,195	17,608	19,521	1,913	10.9%
Total, Idaho Operations Office	22,195	17,608	19,521	1,913	10.9%
Nevada Operations Office					
Nevada Operations Office	0	250	0	-250	-100.0%
Oak Ridge Operations Office					
Office of Scientific and Technology Information	8	8	11	3	37.5%
Oak Ridge National Laboratory	15,301	14,927	17,767	2,840	19.0%
Oak Ridge Operations Office	6,101	5,866	12,351	6,485	110.6%
Total, Oak Ridge Operations Office	21,410	20,801	30,129	9,328	44.8%

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Richland Operations Office					
Pacific Northwest National Laboratory	987	809	1,789	980	121.1%
Oakland Operations Office					
Lawrence Berkeley National Laboratory . . .	1,768	1,233	4,044	2,811	228.0%
Lawrence Livermore National Laboratory . .	2,100	2,107	2,227	120	5.7%
Oakland Operations Office	0	0	1,274	1,274	100.0%
Total, Oakland Operations Office	3,868	3,340	7,545	4,205	125.9%
National Energy Technology Laboratory.	3,150	2,718	4,509	1,791	65.9%
Headquarters	\$32,358	\$34,823	\$46,737	\$11,914	34.2%
Subtotal, Solar and Renewable Resources Technologies	\$332,319	\$310,116	\$409,500	\$99,384	32.0%
Adjustment.	-1,011	0	0	0	0.0%
Total, Solar and Renewable Resources Technologies	\$331,308	\$310,116	\$409,500	\$99,384	32.0%

Site Description

Albuquerque Operations Office

Albuquerque Operations Office (ALO) is a Department of Energy Office located in Albuquerque, New Mexico. ALO provides procurement services and oversight of funding for work being conducted at Golden Field Office, Los Alamos National Laboratory, National Renewable Energy Laboratory, Sandia National Laboratories, and the six DOE Regional Offices located in Atlanta, GA, Boston, MA, Chicago, IL, Denver, CO, Philadelphia, PA, and Seattle, WA. The Regional Offices provide outreach for the Million Solar Roof Initiative. The Albuquerque Office serves as the funding office for the Cooperative Agreements at the University of Alaska and MIT, respectively, to conduct Hydrogen research and development activities in fuel cells for remote power and plasma reforming.

Los Alamos National Laboratory

Los Alamos National Laboratory (LANL), located in Los Alamos, NM, conducts research on the Hydrogen and Electric Energy Systems High Temperature Superconductivity programs.

The Los Alamos National Laboratory serves as the lead laboratory for Hydrogen in the research and development of proton exchange membrane fuel cells for direct hydrogen applications. This includes the application of new material systems, components, and construction techniques to meet the efficiency and cost targets associated with their industry Cooperative Research and Development Agreements (CRADAs). LANL has identified a number of critical technologies to produce the most advanced fuel cell stacks with very low parasitic power requirements.

LANL is the primary laboratory in the Electric Energy Systems High Temperature Superconductivity Program working with industry to develop second generation HTS wires based on the ion beam assisted deposition (IBAD) process pioneered by LANL. LANL's unique expertise in film deposition processes, and materials science is used to improve the performance of IBAD wires. Commercial versions are expected to be able to carry 1000 amperes of current through a centimeter wide metal strip coated with a film the thickness of only a few human hairs - a revolutionary change. LANL is also developing superconducting transmission cables and superconducting fault current limiters (a device that protects the electrical system against lightning strikes and other accidents).

National Renewable Energy Laboratory

The National Renewable Energy Laboratory (NREL), located in Golden, Colorado, conducts research and development for the Solar Buildings Technology Research, Photovoltaic Energy Systems, Concentrating Solar Power, Biomass Power, Biofuels Energy Systems - Transportation, Wind Energy Systems, Geothermal, Hydrogen and Electric Energy Systems and Storage programs.

NREL serves as the lead laboratory for the Solar buildings Technology Research Program. The goal of this program is to combine solar energy technologies with energy efficient construction techniques, and to create cost-effective buildings that have a zero net need for fossil fuel energy on an annual basis. NREL

supports this by managing technical tasks subcontracted to universities and industry and the development of low cost solar collectors for water or space heating. In addition, NREL coordinates related technical activities with the Sandia National Laboratory, the Photovoltaics program, and the Office of Building Technology, State and Community Programs.

NREL is the lead laboratory for the National Photovoltaic R&D program. NREL conducts fundamental and applied materials research on photovoltaic devices, photovoltaic module reliability and systems development, data collection and evaluation on solar radiation, and implements cost-shared government/industry partnerships. Basic research teams investigate a variety of photovoltaic materials, such as amorphous silicon, polycrystalline thin films, high-efficiency materials and concepts, and high-purity silicon and compound semiconductors. NREL conducts simulated and actual outdoor tests on photovoltaic cells, modules and arrays. The test results are used in developing standards and performance criteria for industry.

In the Concentrating Solar Power (CSP) Program, as mentioned earlier, NREL has teamed-up with SNL to form “Sun♦Lab” — a virtual laboratory which employs the synergies of both labs working together under a single management team. Within Sun♦Lab, NREL contributes significantly to the advancement of CSP technologies and provides leadership in strategic program planning. NREL also facilitates input and review by industry stakeholders in the formulation of goals and activities, along with annual and multi-year plans which provide concise documentation of program directions, objectives, milestones and other metrics. In addition, NREL is the site of the High-Flux Solar Furnace which can generate solar concentration between 2000 and 20,000 suns, for use in applied research on advanced materials and processes.

NREL is the lead laboratory in support of Biomass/Biofuels Energy Systems - BioPower Program technologies including those based on combustion and gasification of biomass feedstocks. NREL is responsible for the development of advanced analytical methodologies (chemical and life-cycle) that are used to facilitate industry commercialization, including complete economic assessments of the relevant biomass technologies. NREL works with industry and academia to arrive at consensus points on technology costs and environmental performance. NREL also developed and operates a Thermochemical Users Facility. This state-of-the-art facility enables the private sector to cost-effectively test their power generating technologies in a fully-instrumented pilot facility.

NREL is the lead laboratory for the Biofuels-Transportation Program. The Laboratory conducts biotechnology research and engineering development of biological systems for the conversion of biomass to fuels and chemicals, such as ethanol. Also, the Biofuels Program has established the Alternative Fuels User Facility at NREL which includes laboratories, integrated bench scale process equipment, and a one ton per day process development unit.

NREL is the lead laboratory for the National Wind Energy Systems Program, performing research in aerodynamics, structural dynamics, and advanced components and control systems related to wind energy. The National Wind Technology Center, located at NREL, provides research and testing facilities for fatigue testing of turbine blades, dynamometer testing of wind turbine drive trains and generators, atmospheric testing of turbines, and certification testing which is required for sales and operation in many overseas markets.

NREL provides assistance to Solar Program Support Electric Restructuring Program by maintaining the Restructuring web site and by providing analyses on an as-needed basis on restructuring impacts on

renewable technology development and deployment. NREL will provide technical support to field validation projects and Tribal Colleges under Open Solicitation.

NREL is the lead laboratory for the International Solar Energy interagency program seeking to mobilize private investment in clean energy technologies identified as climate change and development priorities by key developing and transition countries. NREL also participates in providing technical assistance in identifying and developing energy policies that will reduce greenhouse gas emissions and contribute to development goals through accelerated deployment of RE&EE technologies. In addition, NREL will work cooperatively with the private sector.

NREL provides on-going research and development in energy conversion technologies for Geothermal Energy Systems Research and Testing. The laboratory also supports the Geothermal Program in the areas of education, outreach and systems analysis.

NREL serves as the lead laboratory in the Hydrogen research and development of technologies that will offer longer-term solutions to the production and storage of hydrogen for large scale use. NREL is conducting research and development on material systems for the storage of hydrogen using carbon nanotubes and the photoelectrochemical production of hydrogen using semiconductors. NREL is conducting research and development to engineer biological organisms and systems to split water into hydrogen and oxygen and the thermoconversion of biomass to hydrogen. This R&D is in collaboration with the Oak Ridge National Laboratory and the University of California at Berkeley. NREL supports the design of new processes and facilities to produce and use hydrogen through engineering calculations and cost evaluations.

NREL serves as the lead laboratory for the Electric Energy Systems and Storage Transmission Reliability, Distributed Power Program. The laboratory works with industry to develop a uniform national standard for interconnection of distributed power resources with the electric grid and performs research to develop related test and certification procedures. NREL also performs analysis addressing regulatory and institutional barriers to distributed power and provides technical assistance to state agencies and others on these issues.

Sandia National Laboratories

Sandia National Laboratories (SNL), located in Albuquerque, NM, Livermore, CA and Tonapah, NV, perform research for the Solar Buildings Technology Research, Photovoltaic Energy Systems, Concentrating Solar Power, BioPower, Wind Energy Systems, Geothermal, Hydrogen, and Electric Energy Systems and Storage programs.

As the lead engineering laboratory for the Solar Buildings Technology Research Program, SNL works with manufacturers to assist them in lowering the cost of solar products by introducing advanced manufacturing practices. SNL also provides technical support to assist builders and utilities in overcoming problems with the design or installation of solar water heating systems.

SNL supports the Photovoltaic Energy Systems Program with the principal responsibility for crystalline cell research, and systems and balance-of-systems technology development and reliability. Cell research activities support promising new concepts and innovative device fabrication techniques. Indoor and outdoor measurement and evaluation facilities provide support to industry for cell, module, and systems

measurement, evaluation and analysis. Systems level work concentrates on application engineering reliability, database development and technology transfer.

In the Concentrating Solar Power (CSP) Program, SNL has teamed-up with the National Renewable Energy Laboratory (NREL) to form “Sun♦Lab” — a virtual laboratory which employs the synergies of both labs working together under a single management team. Within the Sun♦Lab, SNL provides technical oversight and serves as the lead laboratory in the development of reliable, economically-competitive CSP technologies such as solar dish systems, parabolic troughs, and power towers. SNL is also the home of the National Solar Thermal Test Facility (NSTTF), which covers 110 acres and includes six distinct test areas: the Central Receiver Test Facility with a central tower and 222 heliostats; a 16-kW Solar Furnace; the Modular Solar Industrial Retrofit Trough Facility; the Engine Test Facility; the Distributed Receiver Test Facility; and a newly added 10-kW Remote Solar Dish System, which will serve as a test-bed for advanced dish components. DOE has designated the NSTTF and the Solar Furnace as National User Facilities where qualified researchers from industry, academia, and other laboratories can use the facilities, making it possible for high-risk, high-payoff technologies to be developed and tested.

In support of the Biomass/Biofuels Energy Systems - BioPower Program, SNL provides technical expertise on the combustion processes involving biomass. Emphasis is on slagging and fouling in cofiring operations. Technical and field management support to the modular systems development program is provided as well.

The SNL Wind Energy Department staff work closely with counterparts at the National Renewable Energy Laboratory to provide the Wind Energy Systems Program and the U.S. wind industry with engineering expertise to further the program’s knowledge and goals.

Under Solar Program Support, SNL will provide technical support to field validation projects at Tribal Colleges from Open Solicitations.

SNL serves as the lead laboratory for coordination of the Geothermal drilling research. In cooperative projects with the U.S. geothermal industry, SNL performs research on advanced drilling systems including diagnostics-while-drilling, drilling measurement and control, drilling hardware development, and design and testing of high-temperature wellbore instrumentation. SNL coordinates the activities of universities and commercial research firms to rapidly bring promising geothermal drilling and instrumentation technologies to commercial availability.

For the Hydrogen Program, the Sandia National Laboratory in California serves as the lead laboratory in the development of metal hydride storage materials and systems for various end use applications. SNL performs a spectrum of research and development tasks and other technical support to produce an advanced class of reversible metal hydride materials that have over 5 percent by weight hydrogen stored at a low dehydrating temperature. SNL is capable of producing metal hydride materials for use in research and validation projects. SNL also serves as the lead for the design and implementation of hydrogen systems for remote power applications.

In the Electric Energy Systems and Storage Programs Transmission Reliability, Sandia National Laboratories are part of a national laboratory/industry/university consortium that was formed to support research on Transmission and Reliability, a new initiative in FY 1999. SNL is participating in planning and design of simulations and field testing on a distributed technologies test bed, developing and demonstrating computer simulation for distributed controls in the management of the operation of

regional power systems, and developing risk-based analytical methods for assessing reliability in power systems.

SNL supports the Electric Energy Systems and Storage High Temperature Superconductivity Program by applying their ceramics expertise to developing advanced conductors based on chemical deposition process.

In support of the Electric Energy Systems Energy Storage Program, Energy Storage Program, SNL develops improved energy storage systems components including power conversion electronics and modular multi-functional energy storage systems. SNL characterizes the performance of integrated systems with customer-site data collection and identifies and evaluates the benefits of storage technologies in specific applications. SNL cooperates with industry partners in implementing the Program to increase awareness of the benefits of energy storage and options of providing storage alternatives.

Golden Field Office

The Golden Field Office (GO) located in Golden, CO, provides procurement services and oversight of work being performed at the National Renewable Energy Laboratory.

GO manages the Solar Rating and Certification Corporation grant for the Solar Buildings Program. This grant enables the solar industry to develop voluntary standards on the performance and reliability of solar water heaters.

GO manages two projects for the Photovoltaic Energy Systems Program, which are designed to increase market penetration and integrate PV product development. These projects are the Technology Experience to Accelerate Markets in Utility Photovoltaics (TEAM-UP) and the close-out of Building Opportunities in the United States for Photovoltaics (PV:BONUS) programs. GO utilizes cooperative agreements and requests for proposals to help industry realize the benefits of using photovoltaic systems and devices.

In the Concentrating Solar Power Program (CSP), GO assists DOE headquarters in program management and serves as the funding vehicle for direct contracts with private industry and/or universities. As project managers, the Contracting Officer and the Project Officer are responsible for all technical and contractual requirements associated with the successful conduct and completion of projects. GO is currently managing a new university solicitation for small dish-based solar systems.

GO administers and manages Biomass/Biofuels Energy Systems - BioPower Program projects. These range from the Vermont gasifier project, to advanced technologies that convert biomass-wood and agricultural crops and waste to electricity. Many of these projects target currently unused, rural farmland for growing dedicated energy crops.

Working with HQ program staff, GO administers and manages cooperative agreements for the Biofuels Energy Systems - Transportation Program's cellulose to ethanol demonstration projects. GO also competitively procures, administers, and manages projects designed to develop innovative technologies for the production of ethanol and co-products.

The Golden Field Office will continue to provide support for existing and new cooperative agreements for regional field verification projects with both small and utility size wind turbines under the Wind Energy Systems Program.

GO administers the Renewable Energy Production Incentive (REPI) Program. REPI encourages the acquisition of renewable generation systems that use solar, wind, geothermal or biomass technologies, by state and local governments and non-profit electric cooperatives by providing financial incentive payments for their electric production from available appropriations.

GO will issue and administer competitive solicitations and, in conjunction with Denver Regional Office, manage projects for the Solar Program Support Open Solicitation.

GO works with DOE Solar International Energy program managers in the over all operation and management of an African Initiative for capacity building and project identification and development. These activities include contractual relation with industry partner and educational institutions. In addition, GO supports DOE's activities in the Umbrella Group of nations that share U.S. views on Climate Change issues. This includes support to create joint implementation offices.

The Golden Field Office provides Hydrogen procurement services and technical oversight of the work conducted by the recipients of our Cooperative Agreements. This includes research and development in the areas of production, storage and utilization, and validation of these technologies integrated into subscale systems.

GO manages the Superconductivity Partnership Initiative (SPI) for the Electric Energy Systems and Storage High Temperature Superconducting R&D Program. The SPI is 50% cost-shared with industry and consists of six projects to develop first-of-a-kind designs for more efficient power cables, transformers, industrial motors and flywheel energy systems.

Chicago Operations Office

The Chicago Operations Office (CH), located in Argonne, IL, administers activities in the International Solar Energy program. CH administers the competitive procurement for international project development and joint implementation initiatives in Eastern Europe and Latin America and Caribbean countries.

The Chicago Operations Office administers and manages the Hydrogen program's Cooperative Agreements with recipients conducting research and development for advanced storage concepts and reformers.

Argonne National Laboratory

Argonne National Laboratory (ANL), located in Argonne, IL, performs research and development for the Electric Energy Systems High Temperature Superconducting R&D (HTS) Program. Argonne utilizes unique expertise in ceramics, and materials science to improve conductor performance and to investigate deposition processes, such as metal-organic chemical vapor deposition (MOCVD), which are potentially scalable by industry for a second generation of HTS conductors. Unique facilities such as the Intense Pulsed Neutron Source (IPNS) and the Advanced Photon Source are used for measurement and

characterization in ANL's research. Argonne also performs research on superconducting electric motors, transmission cables, and flywheel electricity systems.

ANL is providing the lead program support for the BioEnergy Initiative's Outreach efforts.

Brookhaven National Laboratory

Brookhaven National Laboratory (BNL), located on Long Island, NY, performs research and development for the Photovoltaic Energy Systems Program. BNL has the responsibility for environmental, health and safety (ES&H) impacts associated with photovoltaic energy production, delivery and use. BNL conducts ES&H audits, safety reviews and incident investigations, and assists industry to identify and examine potential ES&H barriers and hazard control strategies for new photovoltaic materials, processes and application options before their large-scale commercialization.

BNL supports the HTS program by working with National Laboratory/industry teams and universities to undertake research on fundamental wire processing and application issues.

For the International Solar Energy Program, BNL has responsibility for providing technical assistance to developing and transition countries in the use of MARKAL model which has been internationally accepted for use in analyzing the mitigation imports of various strategies under consideration by these countries. In addition, BNL would provide support to selected countries in establishing joint implementation offices.

Idaho Operations Office

The Idaho Operations Office (ID), located in Idaho Falls, ID, provides procurement services and oversight of funding for the Idaho National Engineering and Environmental Laboratory. ID also administers Solar and Renewable Energy programs such as the Renewable Indian Energy Resources and the Hydropower Programs, and is the principal Operations Office for the Geothermal Program.

The DOE Idaho Operations Office has been responsible for detailed planning, management and implementation of the Hydropower Program since 1977.

Idaho National Engineering and Environmental Laboratory

Idaho National Engineering and Environmental Laboratory (INEEL), located in Idaho Falls, ID, performs research and development for the Hydropower and Geothermal Programs. INEEL has been the principal DOE laboratory for the Hydropower Program since the program's inception in 1977. INEEL serves as the engineering technical monitor for the Advanced Hydropower Turbine System Program and the Renewable Indian Energy Resources hydropower projects located in Alaska.

INEEL serves as the lead laboratory for coordination of Geoscience and Supporting Technologies. In cooperative projects with the U.S. geothermal industry, INEEL performs research on fluid flow and solute transport modeling in hydrothermal reservoirs and conducts site investigations of geothermal resource potential. INEEL coordinates and interacts with other National Laboratories, universities, and

commercial research institutions to optimize and consolidate their contributions to technology development and thereby enable greater use of geothermal energy resources.

The Idaho National Engineering and Environmental Laboratory has been the principal DOE laboratory for the Hydropower Program since 1977 (when the program was initiated). Since 1977, INEEL has served as technical monitor, and in some cases responsible for solving financial and technical problems, for 55 feasibility studies, and 18 technology development projects in 16 states with a total capacity of 128 MW; and assisted with 34 engineering R&D projects, developing technology advances such as low-cost crossflow turbines and marine thrusters as turbines. During the late 1970's and early 1980's, INEEL administered the DOE Small Hydropower Loan Program. In addition, INEEL performed the engineering and economic analyses for the recent DOE hydropower environmental mitigation study, and developed the uniform criteria, standardized methodology and software for the DOE hydropower resource assessment activity. Currently, INEEL is serving as the engineering technical monitor for the Advanced Hydropower Turbine System Program and the Renewable Indian Energy hydropower projects in Alaska.

Nevada Operations Office

Nevada Operations Office provides technical and management assistance to develop an integrated hydrogen refueling station in Nevada, including coordination with the Department of Transportation.

Oak Ridge Operations Office

The Oak Ridge Operations Office (OR), located in Oak Ridge, TN, provides procurement services and oversight of funding for the Oak Ridge National Laboratory and the Office of Scientific and Technology Information. OR also administers the Solar and Renewable Energy Biomass/Biofuels Energy Systems Bioenergy Feedstock Development Program (BFDP) to develop new and improved sources of biomass feedstocks for biomass energy systems. This effort includes crop development, environmental research, residue and forests research, resource economics, demonstration project support and evaluation, and communication.

Office of Scientific and Technology Information

The Office of Scientific and Technology Information (OSTI), located in Oak Ridge, TN, performs standard distribution for all programs under the Office of Power Technologies including: Photovoltaic Energy Systems; Concentrating Solar Power; Biomass/Biofuels Energy Systems; Wind Energy Systems; Geothermal; Hydrogen Research; and the Electric Energy Systems High Temperature Superconductivity Programs. This distribution consists of publishing and maintaining on-line full text of eight electronic current awareness publications and the production of CD-ROM disks containing Photovoltaic reports.

Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL), located in Oak Ridge, TN, manages the Bioenergy Feedstock Development Program (BFDP) to develop new and improved sources of biomass feedstocks for BioPower systems. ORNL provides technical leadership for the program and actively fosters alliances among universities, other government agencies and industry. Major current components of the BFDP include energy crop development, environmental research, residue and forests research, resource economics, demonstration project support and evaluation, and communication. These efforts are closely coordinated with the National Renewable Energy Laboratory and the Sandia National Laboratories' programs.

ORNL will provide technical support to field validation projects and Tribal Colleges for Open Solicitations under Solar Program Support.

In the International Solar Energy Program, ORNL has senior responsibility for providing technical assistance to developing countries in the Asia-Pacific region. This assistance includes training in the use of various models for analyzing various options for mitigating and sequestering greenhouse gas emissions as well as establishing joint implementation offices and identifying and developing joint implementation projects.

ORNL performs Hydrogen research and development activities in photobiology and storage in support of the lead labs, NREL and SNL, respectively. ORNL has developed a collaboration with NREL and UC Berkeley to develop a microalgae system for the production of hydrogen. ORNL is using their expertise to integrate engineered biological systems from NREL and UC Berkeley into a base organism that directly produces hydrogen. ORNL is conducting research on carbon based materials to determine the mechanism of hydrogen absorption and the characteristics of desorption.

ORNL's expertise is nationally acknowledged both by industry and other Federal agencies active in the hydropower field. Recently, ORNL provided the environmental analysis for the DOE hydropower environmental mitigation study, and the lab's ORNL environmental scientists and fisheries biologists perform hydropower environmental impact studies for the Federal Energy Regulatory Commission. ORNL currently has the primary responsibility for environmental analysis and as environmental technical monitor for the Advanced Hydropower Turbine System Program, including technical oversight of laboratory biological experiments on stresses experienced by turbine-passed fish.

In support of Electric Energy Systems and Storage Transmission Reliability, ORNL is part of a national laboratory/industry/university consortium that was formed to support research in Transmission Reliability, a new initiative in FY 1999. ORNL is performing: electric power system studies related to the impact of distributed resources on electric power systems reliability, design assistance for a test bed for field or simulation testing of distributed resource concepts, and analyses of alternative market designs for ancillary services in competitive markets.

The Oak Ridge National Laboratory is the primary laboratory in Electrical Energy Systems High Temperature Superconductivity (HTS) Program developing second generation HTS wires based on the rolling-assisted biaxially textured substrate process (RABiTS) patented by ORNL. Five private companies have licenced this technology and are working with ORNL to scale up these discoveries. ORNL's expertise in metals and ceramics is used to address materials science issues in doing this scale up. ORNL is also applying its expertise in cryogenic systems and power system technology in projects to develop superconducting transformers and transmission cables.

ORNL provides experimental data for the modeling and testing of chemical reactions in geothermal brines for the Geothermal Energy Systems Program.

Richland Operations Office

The Richland Operations Office (RL), located in Richland, WA, provides procurement services and oversight of funding for the Pacific Northwest National Laboratory.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL), located in Richland, WA, performs on-going research and technical assistance for the International Solar Energy Program, the Advanced Hydropower Turbine System Program, and the Electric Energy Systems and Storage Program.

PNNL provides technical assistance for the International Solar Energy Program to transition counties for emission trading and developing joint implementation projects. In addition, PNNL participates in the evaluation of joint implementation proposals and in preparing reports on the U.S. Joint Implementation Program.

The Pacific Northwest National Laboratory is providing biological testing support for the Advanced Hydropower Turbine System Program. PNNL has designed and fabricated test equipment to simulate turbine-induced physical stresses on fish, and is currently conducting experiments on shear stresses. These experiments are conducted under ORNL technical direction and oversight.

In support of Electric Energy Systems and Storage Transmission Reliability, Pacific Northwest National Laboratory is part of a national laboratory/industry/university consortium that was formed to support research on Transmission and Reliability, a new initiative in FY 1999. PNNL conducts evaluations of the technological and institutional aspects of recent reliability events on the Nation's electric power system.

Oakland Operations Office

The Oakland Operations Office (OAK), located in Oakland, CA, provides procurement services and oversight of funding for the Lawrence Berkeley and the Lawrence Livermore National Laboratories.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL), located in Berkeley, CA, performs analyses of opportunities for Wind Energy applications in the restructured electricity market and administers various utility restructuring activities under Solar Program Support Electric Restructring. In support of utility restructuring, LBNL conducts policy and technical analyses on utility regulatory policies at the state and federal levels. LBNL provides technical support to state organizations such as the public utility commissions and state energy offices on utility restructuring issues. LBNL provides guidance and support to the private and public market components of the utility industry, including the energy services industry, regional market transformation consortia, and public and private utilities. LBNL also supports

the analyses and proposed implementation of the Administration's proposed legislation on utility restructuring.

For International Solar Energy, LBNL also provides technical assistance to developing countries in assessing the impacts of climate change, the effects of various mitigation strategies, and in the establishment of joint implementation offices and developing an institutional capacity to assess the impacts of these projects.

In support of Electric Energy Systems and Storage Transmission Reliability, Lawrence Berkeley National Laboratory is the managing laboratory for a national laboratory/industry/university consortium that was formed to support research in Transmission Reliability, a new initiative in FY 1999. This consortium is implementing the DOE FY 1999 Transmission Reliability program. LBNL is conducting development work related to modeling studies to assess system benefits of distributed resources on the electric power system, analysis of alternative scenarios for the future operation of electric transmission systems, and the evaluation on market performance of changing markets rules and structures.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL), located in Livermore, CA, performs research and development for the Hydrogen program.

The Lawrence Livermore National Laboratory serves as the lead laboratory in the Hydrogen research and development of a high temperature solid oxide electrolyzer and two different systems for pressurized gas storage of hydrogen. LLNL is developing the materials, technical and engineering data on the preferred configuration for a solid oxide system that will simultaneously reform natural gas to hydrogen using the waste heat for a higher round trip efficiency. LLNL is capable of producing composite storage tanks for environmental testing to verify the advantages of various engineering concepts to increase the storage capacity while reducing the cost of manufacturing. The increase in funding is to enable the fabrication of a breadboard electrolyzer to evaluate the concept in an integrated fashion.

National Energy Technology Laboratory

The National Energy Technology Laboratory (NETL) provides research and development on Solar and Renewable Energy programs with a major emphasis on the Hydrogen Research Program and some on-going research for the Biomass/Biofuels Energy Systems Program. NETL will administer a cooperative agreement with Virginia Accelerator Corporation for an electron scrubbing demonstration project.

NETL provides research and development and technical support for the Biomass/Biofuels Energy Systems - BioPower Program with emphasis on the BioPower cofiring initiative.

Provides co-funding and co-management for a Hydrogen research and development effort to produce an advanced refueling option using catalyzed ceramics in accordance with Memorandum of Agreement with the Office of Fossil Energy.

Headquarters and All Other Sites

The Office of Energy Efficiency and Renewable Energy (EE) funds research at six regional offices located in Atlanta, GA, Boston, MA, Chicago, IL, Denver, CO, Philadelphia, PA, and Seattle, WA, and also provides funding at DOE Headquarters for various Solar and Renewable Energy procurements and interagency agreements in support of the EE mission.

Funds for the In-House Energy Management Program are at Headquarters pending allocation decisions for projects in the field.

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
General Plant Projects	1,869	750	400	-350	-46.7%
General Purpose Equipment	2,031	350	1,500	1,150	328.6%
Total, Operating Expenses	3,900	1,100	1,900	800	72.7%

Solar Building Technology Research

Mission Supporting Goals and Objectives

Program Mission

The Solar Buildings Technology Research Program develops solar technologies that can deliver heat, light, and hot water to residential and commercial buildings. This supports DOE's mission of fostering a secure and reliable energy supply that is environmentally sound and economically sustainable.

Program Goals and Objectives

The focus of the Solar Buildings Technology Program was changed during FY 2000 from the development of low-cost solar water heaters to the more all-inclusive use of solar technology as applied to buildings. The Program's goal is now to optimally combine solar energy technologies with energy efficient construction techniques and create cost-effective buildings that have a zero net need for fossil fuel energy on an annual basis. The result would be "zero energy, zero emission" buildings that not only provide all their own energy from solar energy, but also provide a comfortable environment in which to live or work, as well as a measure of safety from energy disruption due to power outages.

It will accomplish this through the following objectives:

- # **Solar Thermal:** R&D on new polymers and manufacturing processes to reduce the cost of solar water heating and space heating from today's \$0.08/kWh (and higher) to \$0.04/kWh,
- # **Solar Lighting:** research on a new technology that collects sunlight and distributes it into the interior rooms of a building through fiber optics at a cost equivalent to that of conventional lighting,
- # **Technology Coordination:** coordinate a multi-program, crosscutting R&D activity that optimizes the integration of solar energy technologies with energy efficient residential and commercial buildings.

Strategic Approach

The Program's strategic approach is focused on combining the research and development done by the Solar Buildings Program with related research being done by the Photovoltaics Program and the Office of Building Technology, State and Community Programs. It is the combined output from these programs that offer the potential for a package of solar technologies that can economically provide all the energy needed by a building. The three programs fit together as follows:

- # Solar Buildings Program - develop solar technologies that can provide thermal energy for water heating, space heating, and space cooling; and sunlight for lighting interior rooms.

- # Photovoltaics Program (PV) - photovoltaics will provide the electrical needs of the “zero energy” building. Solar Buildings will work with that part of the PV Program that integrates photovoltaics into building design.
- # Office of Building Technology, State and Community Programs (BTS) - the concept of solar energy providing all the energy needed by a building will only be practical for buildings that fully utilize the energy efficient appliances and construction techniques presently being developed by BTS and its partners. Solar Buildings will work closely with BTS on the integration of solar technologies with energy efficient buildings.

This Program will be implemented in partnership with the solar industry, the building industry, and utilities; as well as in close coordination with BTS and the PV program. The program will also work closely with Federal agencies (e.g. EPA, HUD) and state energy offices (e.g. California Energy Commission) that have an interest in reducing the amount of fossil fuels consumed by buildings. Cost sharing from government, utility, builder, and solar industry partners should be approximately \$1.5 million in FY 2001.

DOE support is critical in achieving the goal because the solar industry consists mostly of small companies which do not have the capital resources or in-house technical expertise to overcome the technical barriers which inhibit the introduction of solar technology into the buildings construction market.

These technology development activities support DOE’s strategic goal of promoting the development of competitive and environmentally sound energy markets in the U.S.

Program Benefits

At the proposed funding levels, the Solar Building Technology Research Program is expected to yield the following benefits:

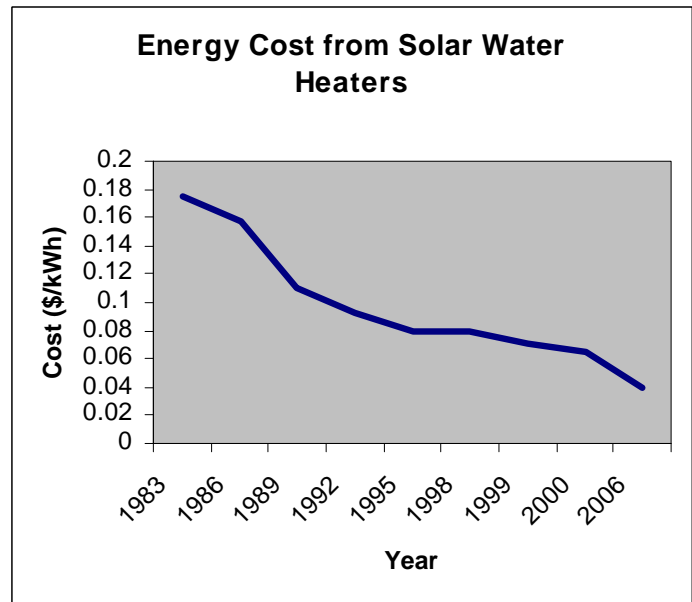
Metrics	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.030	0.06	0.16
Energy Savings (\$ Billions)	0.22	0.39	1.00
Carbon Displaced (MMTCE)	0.50	0.93	2.46

These benefits are derived from displaced energy consumption in buildings which collectively consume 36% of the primary energy used in the U.S. at an annual cost of over \$220 billion. Buildings consume 66% of the nation’s electricity, and are responsible for 35% of the nation’s carbon emissions. With the addition of solar technology, each roof (and many walls) of these buildings can be transformed into valuable energy producers. Hence, each building will become a distributed energy generator that provides itself energy security from natural disasters and extended power outages.

Sunlight, however, can do more than simply provide energy. A 1999 study commissioned by the Pacific Gas and Electric Co. found that students who took their lessons in classrooms with more sunlight

outperformed their peers working under artificial light by between 7 and 25%. The California Energy Commission is now sponsoring a study that explores this effect on the productivity of workers. Thus, the use of hybrid solar lighting may not only save energy, but also lead to smarter students and more productive workers. An increase in worker productivity of only 1% would double the economic value of hybrid lighting.

Solar technologies today are much less expensive and more reliable than ever before (for example see curve showing the progress made in solar water heaters). However, their cost remain too high to compete effectively with low priced energy except in limited areas of the country. Further cost reductions are needed if the technology is to become a widespread economic option and a common addition to buildings. Research being conducted by the Solar Buildings Program and other DOE programs is addressing that need by working toward a new generation of solar technology. The metrics listed here and the goal of a zero energy building assume that long term solar technologies and energy efficiency cost goals will be reached by 2010.



Performance Measures

FY 2001 Performance Measures

- # Prototype solar water heaters will be built that have the potential for achieving the \$0.04/per kWh energy cost goal.

FY 2002-2006 Performance Measures

- # Achieve \$0.04 per kWh (projected delivered energy cost) for solar water heating systems primarily through the utilization of polymer materials and innovative new designs. This will translate to a homeowner being able to buy a solar water heater for about \$1,000, or having the cost included in a mortgage resulting in a monthly incremental payment which is less than the monthly energy savings generated by the system.
- # Reduce the cost premium for a “zero energy” home by approximately 20% by FY 2006. For example, in a Southwest climate, the extra monthly cost for a “zero energy” home compared to a “typical” home would be reduced from \$380 to \$310. (See chart.)

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

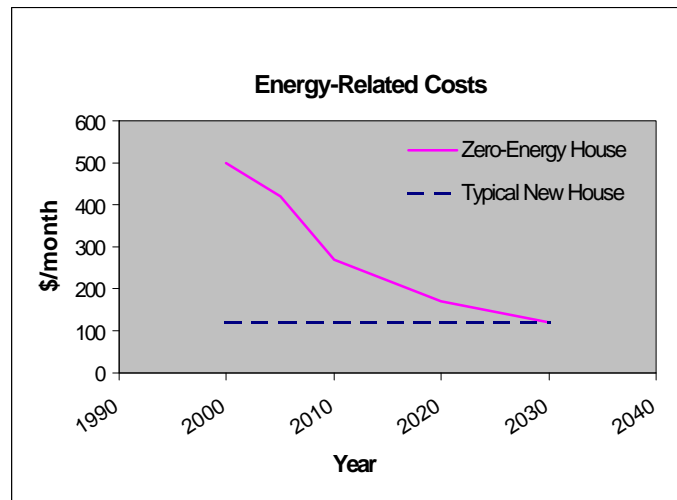
- # Developed solar domestic water heating systems with levelized energy cost of \$0.08/kWh, a reduction from about \$0.20/kWh in 1980.
- # Developed transpired collector technology for preheating building ventilation air with levelized energy cost of \$0.02/kWh and 30 year lifetimes.
- # A Cooperative Research and Development Agreement was initiated with the Salt River Agricultural Improvement and Power District to develop a low cost solar water heater. Cooperative projects were also established with Eugene Water and Electric Board and Lakeland Electric and Water. Solar water heating projects were established with several builders: including Pulte Homes and CAVCO Industries. Technical support (e.g. system evaluation) was provided to each.
- # Completed first phase of seven industry and three university contracts selected to evaluate concepts that have the potential to significantly reduce solar water heating costs.
- # A Cooperative Research and Development Agreement (CRADA) with Energy Laboratory, Inc. (ELI) led to the development of *Black Crystal*, a selective absorbing coating for solar heat collectors that has the potential for replacing black chrome as the industry standard. Black Crystal does not have the environmental problems associated with electroplating chrome and can be produced with a fraction of the energy.
- # Completed evaluation of four solar absorption A/C concepts. Studies completed during FY 1998 indicate that further solar absorption cooling R&D is not warranted at this time.

FY 1999 Accomplishments

- # Two universities with expertise in polymer science (University of Akron and Colorado School of Mines) were selected to assist in the development of the low cost solar water heater.
- # Completed development of a standardized wind loading rating for solar collectors on roofs.
- # Universities and industry completed feasibility studies of solar water heater concepts exploring the use of low cost materials (e.g. lightweight polymers which offer savings in the cost of the collector and its installation) and components (e.g. heat pipes which could lower cost by eliminating the need for pumps and controllers, and increasing system reliability).
- # Implemented manufacturing improvements that will lead to solar products capable of producing hot water at \$0.07/kWh.

FY 2000 Planned Accomplishments

Energy Supply/
Solar and Renewable Resources Technologies/
Solar Building Technology Research



- # Achieve \$0.07/kWh (projected delivered energy cost) for solar water heating systems through improved manufacturing processes.
- # Industry to complete designs of the low cost solar water heater.

FY 2001 Planned Accomplishments

- # Prototypes of the low cost solar water heater will be built and tested to determine their performance under a variety of simulated operating conditions.
- # Establish exposure tests to determine long term durability of polymer formulations selected for the solar water heating systems.
- # Complete feasibility study of hybrid solar lighting system: determining estimated cost and performance.
- # Formulate design concepts of zero energy buildings (residential and commercial) which have all of their energy provided economically by solar technology.

FY 2002 - 2006 Planned Accomplishments

- # In collaboration with industry and university teams, complete development of solar water heating systems able to provide reliable energy at \$0.04/kWh.
- # Develop and test prototype hybrid solar lighting systems for commercial buildings.
- # Complete design specifications for zero energy buildings. Build, test, and evaluate prototype zero energy home that combines solar technologies with energy efficient building design.

Program Completion

Successful completion of the Solar Buildings Technology program will be attained when solar technology can provide all the energy needs of an energy efficient building at a cost competitive with a similar building built to average national energy standards.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Space Conditioning and Water Heating	3,556	1,968	4,500	2,532	128.7%
Total, Solar Building Technology Research . .	3,556	1,968	4,500	2,532	128.7%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Space Conditioning and Water Heating

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Technology Development

Solar Thermal: Design of low-cost solar water heating concepts will be completed. Cost reduction will be realized through the use of inexpensive polymers, improved manufacturing processes, innovative design, and better integration of the solar collector into the building. Prototypes will be built and tested to determine their ability to withstand overheating and freezing. Universities which are recognized for their excellence in polymer science will be teamed with solar manufacturers to provide the expertise needed for developing the new concepts. The designs will be evaluated to address prototype manufacturing issues. Encouraging improvements in materials produced by the polymer industry in the areas of weatherability and manufacturing provide optimism that the solar technology goal can be achieved. For example, multi-layers of polymers and alloys can now be manufactured inexpensively through new extrusion and blowing techniques. New additives have been developed which give polymers oxidation and ultraviolet resistance. The research challenge is selecting polymers that can perform well and that can survive the outdoor environment for extended periods. Lifetime testing of promising polymer formulations will continue. The low-cost solar collectors developed in this activity will later be adapted to become the basis for solar assisted space heating systems. This activity is supportive of recommendations by the President's Committee of Advisors on Science and Technology to establish an initiative on low cost solar water heaters.

3,456	1,700	2,800
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Solar Lighting: A study will be completed to determine the feasibility of using solar concentrating technologies (e.g. small scale parabolic dishes) with large-core optical fibers to bring sunlight into the interior of buildings. The type of solar collector to mate with the fiber optics will be selected. A proof of concept model to determine

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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baseline configuration, cost, and performance will be built. This activity will be coordinated with DOE's Building Technology, State and Community Programs (BTS), as this light source would have to be integrated with a building's conventional lighting system. This "hybrid" system uses the visible portion of the solar spectrum in its natural form (light) and supplements it with reduced amounts of electric light when appropriate. The infrared portion of the solar spectrum will be focused on crystalline silicon photovoltaic cells to produce electricity, adding a third dimension to this hybrid system. Thus, this completely new technology will provide light and electricity in one discrete system.

0 0 700

Technology Coordination: A system study will be completed that determines the optimum mix of solar technologies to economically supply all the energy needed by energy efficient buildings in representative U.S. climates. The investigation will consider grid-connected buildings with net metering. Solar technology cost and performance targets necessary to achieve cost effectiveness will be determined as a function of geographic location. A solicitation will be issued to explore the potential of integrating solar technology with fossil-fuel based heating systems (e.g. heat pumps and radiant heating). In addition, a competition will be initiated to obtain conceptual designs of zero energy buildings. This work will be coordinated with BTS, which is responsible for developing all energy efficient aspects of buildings.

0 0 1,000

The funding level was determined to be the minimum amount necessary for achieving the technology performance measure by FY 2006 and taking the first steps in determining whether solar energy can lead to a zero energy building.

Total, Technology Development

3,456 1,700 4,500

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Quality Assurance

This activity will no longer be a key element of the Solar Buildings program.

Total, Quality Assurance	100	268	0
<hr/>			
Total, Solar Building Technology Research.	3,556	1,968	4,500
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Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Space Conditioning and Water Heating

Technology Development

# Solar Thermal - Build and test prototype solar water heaters.	1,100
# Solar Lighting - Determine feasibility of bringing sunlight into buildings with fiber optics.	700
# Technology Coordination - Studies will determine best mix of solar technologies that would economically provide all the energy needed by an energy efficient building.	1,000
<hr/>	
Total Funding Change, Technology Development	2,800
 Quality Assurance - Any further reliability related activities will be included in technology development.	
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Total Funding Change, Solar Building Technology Research.	2,532
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Photovoltaic Energy Systems

Mission Supporting Goals and Objectives

Program Mission

The mission of the National Photovoltaics Program is to conduct the research and development (R&D) necessary to enable photovoltaics (PV) to become a significant contributor to the United States domestic energy needs. The resources dedicated to R&D, in partnership with industry and academia, have advanced PV from a laboratory novelty to a growing U.S. industry. The challenge for the DOE PV Program is to continue an effective and productive role in advancing PV technology and maintaining and enhancing a growing U.S. industry.

Program Goals and Objectives

Photovoltaic (PV) solar technology uses semiconductor-based cells to directly convert sunlight to electricity. The greater the intensity of the light, the more power that is generated. PV can be used to produce electricity on almost any scale, depending only on how many PV modules are connected together. The worldwide market for PV is growing rapidly, with the United States retaining the largest market share in 1998.

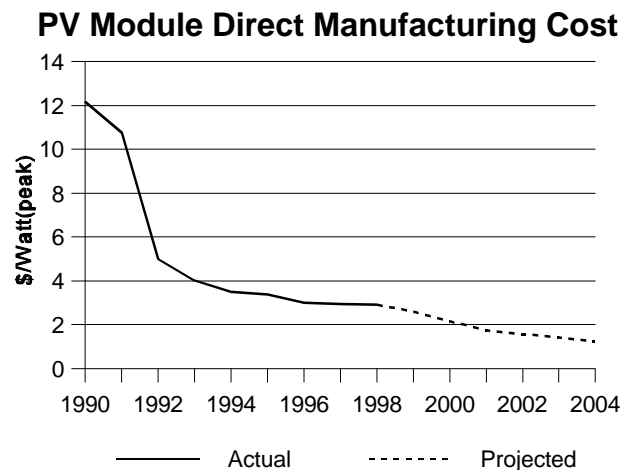
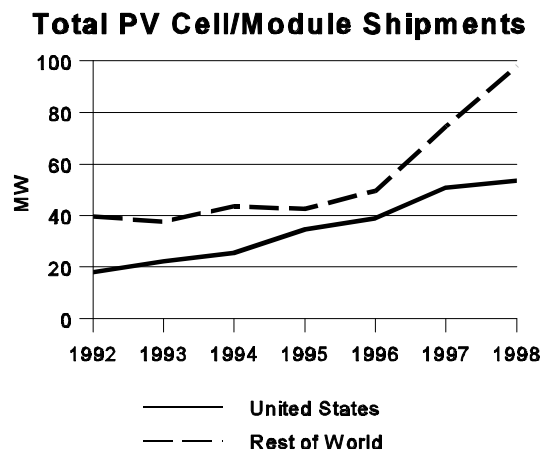
Even though the cost of PV has decreased rapidly over the past decade, it is currently too high for the bulk power market. R&D challenges to reduce costs include improving the fundamental understanding of materials and processes to provide a technology base for advanced PV options, optimizing cell and module materials and design, scaling up cells to product size, validating performance in outdoor and accelerated conditions, and improving manufacturing processes.

By 2004, in partnership with the photovoltaic industry, universities and national laboratories, the National Photovoltaic RD&D Program will:

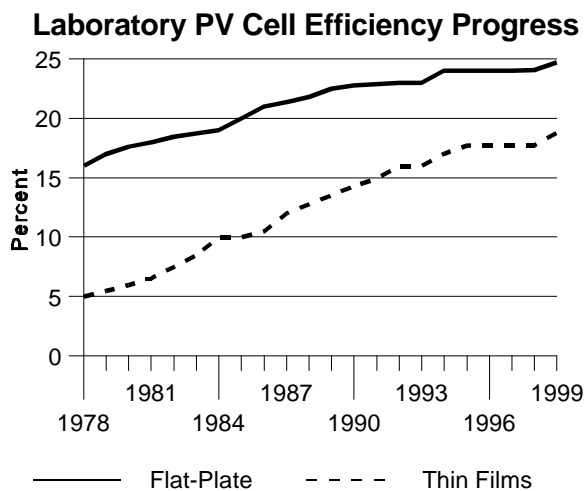
- # Expand U.S. leadership in photovoltaic research by setting new performance records in all leading photovoltaic technologies and by identifying two new promising photovoltaic options for future R&D.
- # Increase the efficiency of thin film modules from the current 7% to 12% in multi-megaWatt production.
- # Reduce the direct manufacturing cost of photovoltaic modules by 40% from the current average cost of \$2.50/watt to \$1.50/watt.
- # Validate greater than 25-year lifetime for PV systems by improving the reliability and lifetime of balance-of-systems components and reducing recurring costs by 50%.
- # Facilitate a U.S. PV industry growth rate of 25% per year, consistent with the vision in the PV Industry Roadmap, to attain a near term goal of 1 gigaWatt cumulative U.S. sales (export and domestic) by 2004 and 30 gigaWatts by 2020.

- # Develop strategies that couple off-grid/mini-grid photovoltaic applications with international rural development plans.

These advancements are necessary to develop cost competitive products that can sustain the emerging PV industry and ensure successful implementation of the President's Million Solar Roof Initiative. By the year 2004 we will have reached 60% of the technical goals and will have introduced products into the market place such that there will be 350 megaWatts of cumulative installed systems in the U.S.



Strategic Approach



The Federal government invests in PV to help establish a domestic energy option that can also protect the environment and foster an emerging high-technology industry that creates high-value jobs. Industry's

stake in opening new markets and applications has increased because of rising competition. DOE's strategy is to concentrate on areas of high-risk, high-payoff research and development where private sector companies traditionally under invest and where DOE has valuable expertise and can make a significant impact with limited funds.

This strategy includes conducting fundamental research on several photovoltaic semiconductor materials to resolve issues that limit current technology, and to conduct basic R&D for breakthrough, non-conventional PV technologies aimed at dramatic cost/kW reductions. In addition, advanced materials and devices work will continue cost-shared research with industry to improve device efficiency and stability, particularly for large-area thin film deposition systems. Developing thin film technologies is a major thrust of the Program and receives the most funding because most scientists agree that thin film technologies have the best chance for attaining the Program's long-term goal of \$0.06/kWh. Process R&D will be conducted by way of 50/50 cost-shared industry research to reduce module manufacturing costs, improve module performance, and stimulate investment in new manufacturing lines. These research activities are core program efforts to develop the advanced technologies that are essential to maintaining U.S. competitiveness in the next 5 to 10 years. To further support the strategy, module reliability research will be conducted to improve lifetime in the field, and system component reliability efforts will be continued to help improve the lifetime of fielded systems. In addition, research and analysis relating to restructuring in the electric utility industry will be conducted on issues associated with integration of PV systems into an increasingly competitive industry framework.

In summary, the FY 2001 budget presents a balanced effort in fundamental and applied research, materials and device development, process R&D, module reliability, and system testing and evaluation. A major portion of this work will be undertaken via competitive procurement resulting in highly leveraged cost-shared projects with the emergent PV industry.

Foreign competition is a growing concern. The U.S. PV industry lost market share in 1998 to the rapidly growing Japanese industry. In 1997, the U.S. PV industry led the world in sales with 41% of the market. In 1998, the U.S. market share had dropped to 35%. In contrast, the Japanese PV industry grew 40% in 1998 and increased their market share from 28% in 1997 to 32% in 1998. If this trend continues, the U.S. PV industry will lose its world leadership to the Japanese this year. The balanced, aggressive set of research activities described in this budget request will maintain U.S. industry growth and momentum, two important ingredients necessary to successfully meet program goals and increase market share.

The Photovoltaics R&D program supports the Million Solar Roofs Initiative (MSR) through reliability and systems development. The MSR seeks to facilitate the installation of photovoltaic and solar hot water systems on one million buildings across our nation by 2010. These installations will result in experience with this technology by electric utilities, engineers, developers and others and decreases in production costs by manufacturers as market demand increases.

Program Benefits

Metrics	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.01	0.02	0.10
Energy Savings (\$ Billions)	0.01	0.05	0.22

Carbon Displaced (MMTCE)	0.12	0.40	1.76
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The DOE National Photovoltaic Program has been key to enabling the U.S. PV industry become a technology and product leader in a very competitive and rapidly growing global marketplace. The U.S. PV Industry Roadmap projects a growth of 25% per year through the year 2020 -- this will result in a cumulative installed capacity in the U.S. of about 1.1 gigaWatts of PV systems in 2010 and 13.3 gigaWatts in 2020.

Performance Measures

FY 2001 Performance Measures

- # Develop a 14%-efficient stable prototype thin-film module.
- # Identify at least three innovative, non-conventional PV materials, devices, and/or processes for further research and development.
- # Complete development of standard test procedures for stand-alone and grid-tied PV system performance.
- # Develop preliminary designs for off-grid/mini-grid PV systems for developing countries.

FY 2002 - 2006 Performance Measures

- # Demonstrate a 20%-efficient thin-film cell and a 35%-efficient concentrator cell in the laboratory.
- # Increase the efficiency of commercial thin-film modules to 12% and crystalline silicon modules to 16%.
- # Test a low-cost, stable module encapsulant compatible with 30-year module life.
- # Test fielded PV systems compatible with 25-year life.
- # Achieve greater than 400 megaWatts of cumulative installed PV systems in the U.S.
- # Develop 10-20 cost-competitive off-grid/mini-grid PV applications for developing countries.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- # Developed an 18%-efficient thin-film solar cell.
- # Achieved commercial sales of 10%-efficient CIS modules by industry (Siemens Solar); commercial production of large-scale amorphous silicon modules started by Solarex (Toano, Virginia) and United Solar (Troy, Michigan). DOE funded R&D directly led to these accomplishments.
- # Several products developed by industry partners were recognized for awards: Advanced Energy Systems and Ascension Technology won awards from Popular Science for alternating-current (AC)

modules, and United Solar won awards from R&D 100, Popular Science, and Discovery magazines for PV roofing shingles.

- # Established nine state and community partnerships for the Million Solar Roofs Initiative in first year of full implementation.

FY 1999 Accomplishments

- # Achieved 19%-efficient CIS cell in the laboratory (NREL) and greater than 12%-efficient CIS module in pilot production (Siemens Solar Industries in Camarillo, California).
- # Completed awards of Future Generation PV R&D subcontracts to 18 universities in 12 States.
- # Completed Phase 2, Preliminary Engineering Development, and initiated Phase 3, Prototype Development/Field Verification, for the PV:BONUS II project.
- # Completed industry consensus on utility interconnection standard (IEEE P929) for PV systems.
- # Established 16 additional partnerships for the Million Solar Roofs Initiative and installed 15,000 solar energy systems.

FY 2000 Planned Accomplishments

- # Develop a 13%-efficient stable prototype thin-film module (either CIS or CdTe).
- # Identify 2-4 new and novel materials and cell devices with potential for low-cost, future generation PV options.
- # Develop low-cost options for 35% high-efficiency concentrator cells.
- # Identify a low-cost, stable module encapsulant compatible with 30-year module life.
- # Install 20,000 solar energy systems in support of the Million Solar Roofs Initiative, bringing the total number of installed systems to 70,000.

FY 2001 Planned Accomplishments

- # Develop a 14%-efficient stable prototype thin-film module.
- # Achieve at least three record efficiencies in laboratory cells and prototype modules.
- # Identify at least three innovative, non-conventional PV materials, devices, and/or processes for further research and development.
- # Demonstrate new, potentially low-cost module encapsulant with greater than 20-year life.
- # Complete development of standard test procedures for stand-alone and grid-tied PV system performance.
- # Develop international acceptance tests for system performance and consensus standards.
- # Install 20,000 solar energy systems in support of the Million Solar Roofs Initiative, bringing the total number of installed systems to 90,000.

Program Completion

In addition to the 5-year goal, the Photovoltaic Program has established long-term goals to ensure steady progress and successful implementation of the Program. Success will be attained when photovoltaics can provide more cost competitive electricity than other forms of electrical generation. The long-term goal is to reach \$0.06/kWh electricity with installed system costs from \$2.00 to \$4.00/Watt. PV must also be more reliable and convenient to use than the next best alternative for each application. Therefore, the program is working towards system lifetimes greater than 20 years, and with manufacturers to simplify system design and develop uniform standards.

Successful completion of the Photovoltaic program will be attained when the cost of PV generated electricity is cost competitive with conventional distributed power generation (\$0.06/kWh). With continued support for a strong and aggressive R&D Program, this goal can be met in the 2010 to 2015 time frame.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Fundamental Research	10,761	14,221	20,300	6,079	42.7%
Advanced Materials and Devices	25,836	27,000	27,000	0	0.0%
Technology Development	33,964	24,691	34,700	10,009	40.5%
Total, Photovoltaic Energy Systems	70,561	65,912	82,000	16,088	24.4%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Fundamental Research

- # **Measurement and Characterization** - Support industry and university research groups in advancing material and cell technologies by characterizing cell materials and devices, and reducing efficiency limiting defects in cell materials. The funding level is considered appropriate based on laboratory scientific staff experience, and through the development of a comparative analysis with similar research activities. Most PV companies cannot afford large teams with expensive laboratory facilities of their own to conduct long-term, high-risk basic research activities. 5,261 5,500 6,000
- # **Basic Research/University Programs** - Improve the understanding of defects in conventional crystalline silicon and thin film materials that limit efficiency. Support research to advance the understanding of cell material growth, deposition processes, semiconductor theory, and characterization methods and standards. Begin second year of university research on new and novel materials and cell devices. Begin first year of 3-year contracts in response to competitive solicitation issued in FY 2000 for basic R&D for breakthrough, non-conventional PV technologies - liquid cells, polymers, biochemical and biomimetic processes, etc. - aimed at dramatic cost/kW reductions. A total of \$1,000,000 was allocated by Congress in FY 2000 for the Materials Science Center in Tempe, Arizona. The funding level is considered appropriate based on laboratory scientific staff experience, and through the development of a comparative analysis with similar research activities. Most PV companies cannot afford large teams with expensive laboratory facilities of their own to conduct long-term, high-risk basic research activities. 5,500 5,021 7,300
- # **High Performance Advanced Research** - In FY 2001, begin first year of 3-year contracts awarded in response to competitive solicitation issued in FY 2000 for the High Performance PV Initiative. In-house laboratory research that provided the foundation for the initial start-up of this activity

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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will be continued and expanded to complement the high priority university/industry contracts. This initiative supports research to substantially increase the efficiency of two key photovoltaic technologies: multijunction concentrating cells and large-area, monolithically interconnected thin films. Fundamental research aimed at major innovations is required to essentially double the conversion efficiency of thin films from their current 8-10% to 15-20%, and to increase III-V-based multijunction cells from 30% to 40% under 500X concentration. In-house national laboratory expertise as well as competitive solicitations to universities and industry will be used to conduct innovative research on thin films and provide insights into III-V-based semiconductor material systems and devices. Both the enhanced thin film approach and the multijunction III-V approach will yield dramatically reduced dollar per watt values for terrestrial photovoltaics. The funding level is considered appropriate based on staff experience and historical precedence in similar research activities.

	0	3,700	7,000
Total, Fundamental Research	10,761	14,221	20,300

Advanced Materials and Devices

Thin Film Partnership Program - In FY 2001, issue new competitive solicitation for 3-year cost-shared contracts with industry and universities to develop the next generation thin film technologies. These R&D contracts will support the near-term transition to first-time manufacturing and scale-up of thin film amorphous silicon, copper indium diselenide, cadmium telluride, and thin silicon; continue progress in terms of performance, reliability and reduced cost; and sustain innovation to accelerate progress toward ambitious long-term goals of 15% modules under \$50/m² capable of lasting 30 years. Research teams made up of leading scientists from industry, universities and national laboratories will continue to work together to define and carry out shared activities. The funding is considered appropriate based on staff experience and historical precedence in similar activities. Developing

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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thin film technologies is a major thrust of the Program and receives strong support because most scientists agree that thin film technologies have the best chance for attaining the Program's long-term goal of \$0.06/kWh.

0 0 19,000

- # Pursue efforts within the thin film partnership program to achieve cost-effective thin film technologies by supporting research teams made up of leading scientists from industry, universities and national laboratories, who work together to define and carry out shared activities. Industry and university participants are selected through competitive solicitations. FY 2000 activities will support the final year of 3-year cost-shared contracts with industry to develop a 13% efficient prototype stable amorphous silicon module; solve degradation of copper indium diselenide (CIS) modules due to water vapor ingress; establish reliable high-throughput, high-yield CIS deposition processes to achieve prototype 13% efficient large area modules; and identify stress induced loss mechanisms for cadmium telluride (CdTe) based cells.

In FY 1999, increased funding for 4-5 additional Thin-Film Partnership industrial contracts to achieve 13% efficient stable amorphous silicon cells; 10% stable amorphous silicon modules; and a large increase in the commercial production of 8.5% efficient CdTe thin film modules. The funding is considered appropriate based on staff experience and historical precedence in similar activities.

17,836 19,000 0

- # **Crystalline Silicon/High Efficiency Devices and Reliability**
Support research on silicon defects and high efficiency devices. Develop innovative silicon crystal growth methods with improved throughput, conversion efficiency, and lower energy and materials cost than current methods. Work with high efficiency concentrator cell industry to develop low cost options for 35% tandem cells. Conduct environmental stress testing of emerging PV modules developed through Thin Film Partnership and PVMaT programs. The funding level is considered appropriate and represents core program efforts to develop the advanced technologies that are essential to maintaining U.S. competitiveness and attaining near, mid- and long-term goals.

8,000 8,000 8,000

Total, Advanced Materials and Devices.

25,836 27,000 27,000

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Technology Development

- # **Manufacturing R&D** - In FY 2001, complete the third year of 3-year manufacturing R&D contracts awarded in 1998 to accelerate cost reductions and produce higher performance modules. These contracts also address manufacturing R&D related to PV system components other than modules, such as batteries and inverters, to improve and reduce overall system costs. In FY 2001, begin first year of 3-year contracts for process diagnostics selected in FY 2000. The funding is considered appropriate based on an extensive industry-wide survey that concluded that manufacturing R&D is the single most effective way to that assist U.S. industry in reducing costs.

In FY 2000, issue a new competitive solicitation to develop new material and insitu process diagnostics needed for PV module scale-up and successful manufacturing. All new contracts meet or exceed 50% cost-sharing. Completed second year of manufacturing R&D contracts awarded in 1998 to accelerate cost reductions and produce higher performance modules.

0 10,000 11,000

- # In FY 1999, fully funded 15-18 new three year PVMaT contracts to improve module manufacturing processes. These contracts are expected to achieve manufacturing cost reductions of 50% from 1996 levels. Completed third year of PVMaT three-year contracts initiated in FY 1996 to reduce manufacturing costs and improve processing of thin film technologies and balance of system components. Awarded additional three-year contracts that emphasized advanced manufacturing technologies for producing higher performance and lower cost commercial thin film and thin silicon modules.

10,364 0 0

- # **Systems Engineering & Reliability** - Increase funding for the module and system reliability program. Conduct system engineering tests to validate the performance, safety, reliability and cost of fielded systems and components. Support development of domestic and international standards and codes, and procedures for certifying performance of commercial systems. Achieve fundamental understanding of

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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photo/thermal/chemical/ environmental factors that influence the stability of encapsulated materials and performance of PV cells in modules. The funding level is considered appropriate based on the critical role system reliability plays in the success of the Program.

Systems engineering and reliability research is critical to achieving the Program's goal of developing modules and systems that can last 30 years in the field. Cost competitiveness for PV generated electricity is directly dependent on payback over the life of the system under actual operative conditions. In FY 2000, reduce funding and maintain only highest priority activities. Provide \$1,200,000 to support ongoing research at the Southeast & Southwest regional experiment stations.

0	12,191	13,200
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In FY 1999, supported efforts to develop codes, standards and safety specifications for building integrated residential and commercial systems. Continued efforts to evaluate and monitor utility grid tied systems. Maintained reliability research to improve system component performance and reduce O&M costs. Provided \$1,500,000 to support ongoing research at the SE and SW regional experiment stations. Collaborated with U.S. industry to increase system and balance-of-systems efficiency and reliability to achieve additional cost-reduction of about 35% for installed systems in the year 2000 (a savings of about \$2.50 per watt from the present \$8.00 per watt for installed systems) and resulting from improved design, efficiency and quality control.

16,000	0	0
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PV Building Integrated R&D - In FY 2001, increase R&D on advanced PV Building concepts, tools, and modeling procedures in support of industry efforts to address technical barriers to expanded markets for PV in the buildings sector. Industry projects substantial market growth for PV integrated products and systems and this R&D will respond to industry's need for continued development. The funding is considered appropriate based on similar product development R&D efforts.

In FY 2000, complete Phase 3: Prototype Development/Field Verification contracts for PV:BONUS II. Assess technical progress and marketing success of PV:BONUS products to

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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determine future activities. The funding is considered appropriate to successfully complete the multi-year PV:BONUS II project.

In FY 1999, funded Phase 2 Preliminary: Engineering Development contracts for PV:BONUS II and initiated Phase 3: Prototype Development/Field Verification by awarding PV Building Integrated contracts to best Phase 2 performers. Provided technical support for accelerated use of renewables in as many as one million new buildings by 2010. The funding is considered appropriate to successfully complete the multi-year PV:BONUS II project and honor all contractual commitments.

2,300	500	1,500
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- # **Partnerships for Technology Introduction** - In FY 2001, issue new competitive solicitation for highly leveraged projects emphasizing building integrated applications, including public and private school buildings. All new projects will exceed 50% cost sharing.

In FY 2000, complete testing and verification of all utility and residential grid-tied PV systems installed through previous energy partnerships. The funding is considered appropriate because efforts to deploy new products and validate them in the field are critical to meeting the Program's goals and strategy to increase user acceptance.

0	500	2,000
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- # No new contracts were awarded in FY 1999. The new projects initiated in FY98 emphasizing building integrated applications were completed and testing and verification activities were conducted in FY99. Completed fabrication of the eight utility grid-tied PV systems under UPVG.

3,800	0	0
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- # **Million Solar Roofs (MSR) Initiative** - In FY 2001, continue efforts to facilitate the expanded deployment of solar systems throughout the U.S. Continue training and outreach programs with all major partnerships.

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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In FY 2000, work on financing mechanisms, measurement and evaluation, technical standards and infrastructure such as net metering capability in support of the State and Local Partnerships. Provide technical assistance to the Partnerships to familiarize them with solar energy technologies to evaluate their capabilities and limitations, and to support consumer education efforts through the Partnerships and in conjunction with utilities. Provide general training and technical assistance to Partnerships, utilities, industry groups, financial institutions and governmental entities. Establishment of a national MSR registry jointly with state and local governments, utilities and other MSR partners will be fully implemented. The funding level is appropriate based on comparative analysis of similar activities. Also fulfills strategic objectives in Presidential Initiative.

0 1,500 3,000

In FY 1999, conducted training workshops on the design, operation, maintenance, and repair of solar technologies. These workshops were for state and local agencies, builders, designers, and developers. Began development of an outreach program to educate consumers about solar technology and familiarize them with the MSR initiative. An additional 15 major partnerships were formed. Partners were provided technical assistance as needed. The funding level is appropriate based on comparative analysis of similar activities. Also fulfills strategic objectives in Presidential Initiative.

1,500 0 0

International Clean Energy Initiative - The goal of this new PCAST initiative is to accelerate the RD&D of photovoltaic technology, including for use in rural development in developing countries, to dramatically increase PV's global energy contribution by 2020. Efforts will be undertaken to 1) develop distributed grid-connected systems and the analytical tools for identifying/evaluating/developing country opportunities for PV distributed systems, 2) develop integrated PV off-grid/mini-grid systems to increase usage for isolated village applications such as schools, clinics and disaster response, and 3) develop international equipment standards that assist open competition. All funds will be competitively awarded

0 0 4,000

Total, Technology Development.

33,964 24,691 34,700

Total, Photovoltaic Energy Systems.

70,561 65,912 82,000

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Fundamental Research

# Measurements and Characterization - Increase measurements and characterization support of industry based on growing demand from research community.	500
# Basic Research/University Programs - Increase necessary to fully fund the 5-7 industry/university contracts selected in FY 2000, and to fully implement the in-house laboratory research that provides the foundation for this activity.	2,279
# High Performance Advanced Research - Increase necessary to fully fund the 12-15 industry/university contracts selected in FY 2000, and to fully implement the laboratory research that provides the foundation for this activity.	3,300
Total Funding Change, Fundamental Research	6,079

Technology Development

# Manufacturing R&D - Increase necessary to begin new cost-shared industry contracts to develop new material and process diagnostics needed for PV module scale-up and more cost-effective manufacturing.	1,000
# Systems Engineering & Reliability - Increase to restore the module and system reliability program at the national laboratories.	1,009
# PV Building Integrated R&D - Increase R&D on PV building integrated technologies to support industry's fastest growth market.	1,000
# Partnerships for Technology Introduction - Increase to issue new solicitation to validate PV systems in the field.	1,500
# Million Solar Roofs (MSR) Initiative - Increase to facilitate the expanded deployment of solar systems throughout the U.S.	1,500
# International Clean Energy Initiative - Increase to accelerate the RD&D of photovoltaic technology, including for use in rural development in developing countries, to dramatically increase PV's global energy contribution.	4,000
Total Funding Change, Technology Development	10,009

Total Funding Change, Photovoltaic Energy Systems.	16,088
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Concentrating Solar Power Program

Mission Supporting Goals and Objectives

Program Mission

The Concentrating Solar Power (CSP) Program is leading the national effort to develop clean, competitive, and reliable power options using concentrated sunlight. Our role at DOE, is to provide innovative and viable technology options that U.S. industry can then take to the marketplace. R&D in CSP technologies will improve our nation's energy security by building toward the economic use of the extensive domestic solar resources that exist in the U.S. CSP technology will also create business opportunities for U.S. industry both here and abroad, resulting in jobs for U.S. workers. In addition, CSP technologies will be able to take advantage of utility restructuring by providing technology options capable of participating in distributed power applications. In the near term, CSP can make a significant energy contribution under state-sponsored portfolio standards and system benefit charge (renewable energy incentive) programs.



Aerial View of Solar Electric Generator Systems (SEGS) at Kramer Junction, California.

Program Goals and Objectives

Ranging in size from several kilowatts (dishes) to multi-megawatt installations (troughs), CSP systems are expected to satisfy substantial domestic and international energy needs, contributing 5,000 MW by the year 2010.

Consequently, CSP systems are also expected to make a significant contribution to the Comprehensive National Energy Strategy (CNES) goals of reducing carbon emissions in the early part of the 21st century (1.3 million metric tonnes annually in the U.S. by 2010), providing future generations with a robust portfolio of clean and reasonably priced energy sources, and promoting the development of open, competitive, international energy markets. CSP technologies will also make a significant contribution to the Office of Power Technologies' objective of tripling non-hydroelectric renewable energy generating capacity by 2010.

CSP technologies use various mirror configurations to concentrate the heat of the sun to produce electric power. Because of their use of heat, all CSP technologies can be hybridized with various fuels to provide high-value dispatchable power on demand. The five-year goal of the CSP Program is to work with U.S. industry to develop reliable distributed CSP systems (i.e., 4,000 hrs. between forced outages) and reduce the cost of dispatchable systems from the current 10-12¢/kWh down to under 8¢/kWh. These attributes,

along with world record solar-to-AC-electric system conversion efficiencies (29.4%), make CSP an attractive renewable energy option in U.S. as well as world-wide sunbelt regions.

Strategic Approach

In response to the changes brought on by utility restructuring and pending changes in U.S. electricity supply, the CSP Program has readjusted its focus toward technologies that can meet distributed electricity supply needs and satisfy desires for dispatchable power from intermittent solar sources. The plan outlines program activities along three paths as described below.

The first path, *Distributed Power Systems*, is focused on developing reliable kW-scale solar technologies that will be used to generate power close to the point of demand. In addition to meeting distributed utility or individual household needs, these systems can satisfy remote power applications where electricity prices are significantly higher than the national average and where near-term market opportunities exist. Emphasis in FY 2001 will be on field testing 25 kW utility-scale dish/engine systems, demonstrating automated off-grid operation of a 10 kW remote power system for Native American applications, and working with both universities and industry to investigate smaller (1-5 kW), mostly solid-state dish-based systems (e.g., high-concentration PV) that will be suited for residential markets. These efforts will result in orders of magnitude improvements in system reliability, and will achieve energy costs capable of serving remote power needs by 2005. (See Table 1).

The second path, *Dispatchable Power Systems*, is focused on reducing the cost of MW-scale solar technologies that can deliver power on demand, even when the sun is not shining. For these systems, dispatchability is achieved either through thermal storage (as demonstrated by the Solar Two power tower with molten-salt) or hybridization with fossil fuel (as demonstrated by the trough plants currently operating in California). While previous U.S. installations of trough systems relied on once-available 25% tax credit for economic viability, recent technology roadmapping exercises with industry have identified major opportunities for cost reductions which are expected to re-open a domestic market for troughs based on present-day economic realities. These advances will also place U.S. firms in a leading position to compete for international trough projects currently before the World Bank. U.S. firms are also competing vigorously for participation in power tower projects expected to be built in response to the Spanish "Royal Decree", where a premium is being offered for solar-only power. Both of these opportunities will lead to a "next generation" of plant designs capable of producing solar power for 6-8¢/kWh within five years. (See Table 2). Since they will be capable of meeting highly-valued U.S. daytime peaking power needs, they will be domestically competitive at these prices.

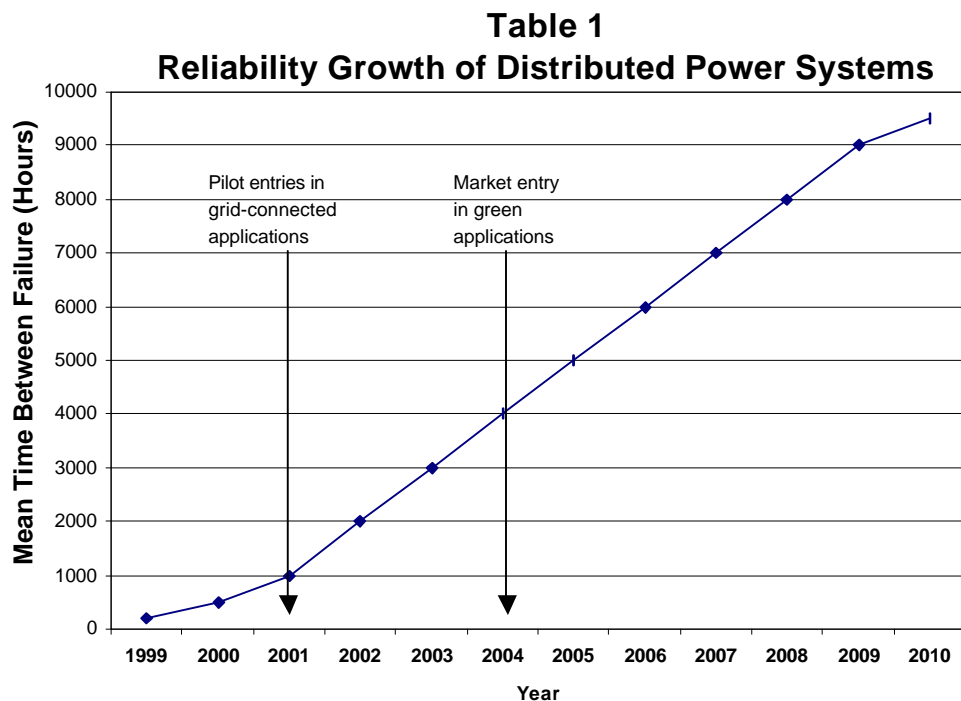
Penetration of broader domestic and international markets depends on advances from higher risk research into advanced technologies. This R&D is performed under the third path, *Advanced Components and Systems Research*. By supporting research on advanced technologies -- such as heat-pipe receivers, high-temperature components, advanced optical materials -- and achieving economies of scale arising from expansion into high-value markets, CSP systems will be able to compete in both dispatchable and distributed markets for 4-6¢/kWh. At these prices, CSP systems will become a self-sustaining component of the domestic energy economy.

Program Benefits

Metrics

	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.01	0.04
Energy Savings (\$ Billions)	0.01	0.04	0.14
Carbon Displaced (MMTCE)	0.06	0.22	0.77

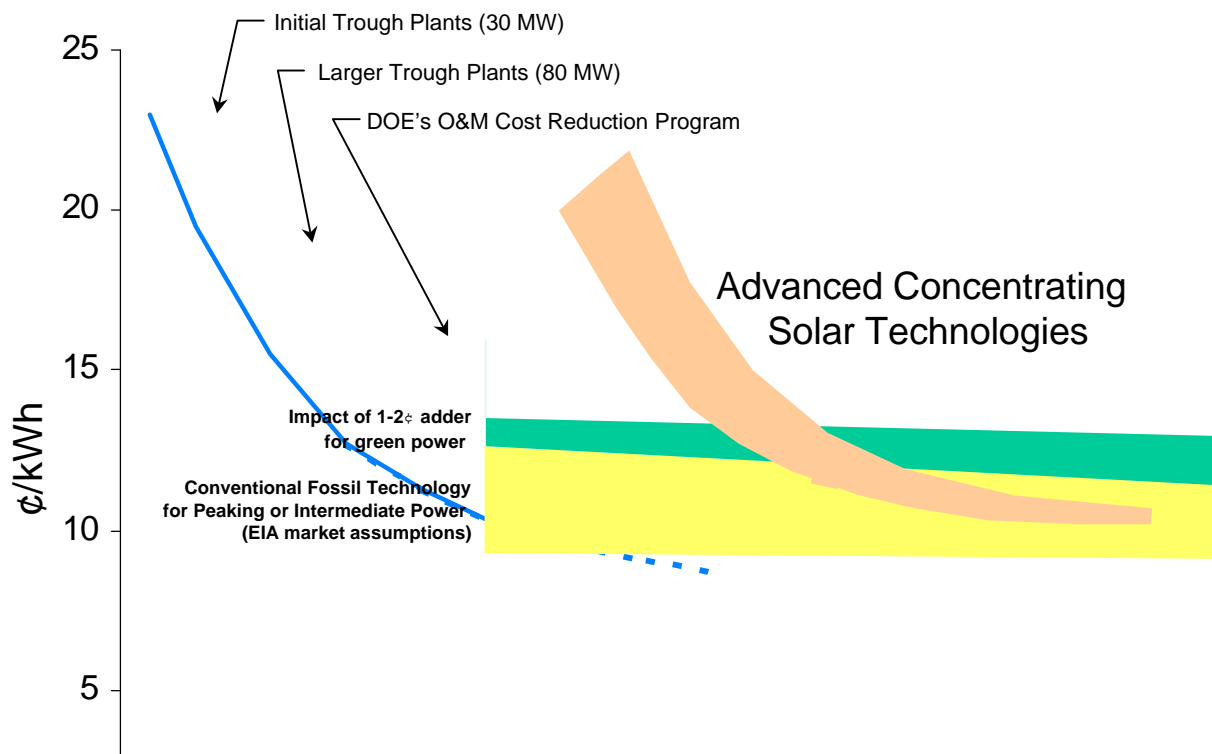
Performance Measures



The highest priority in Distributed Power System Development is to demonstrate reliable system operation. One of the best ways to track progress in this area is to measure the MTBF or mean time between failure. The CSP Program is pursuing an R&D cycle of advanced component development, field testing, and system analysis leading to further component refinements which will be integrated into the next generation of systems. By aggressively pursuing this “reliability growth” model, DOE will make CSP technologies a viable option for near-term green distributed power markets.

Table 2

The Cost of Concentrating Solar Power



The highest priority in Dispatchable Power System Development is to reduce the system energy cost. With current trough technology capable of costs in the 10-12¢/kWh range, the CSP Program has identified R&D opportunities that will bring the levelized energy cost of these systems under 8¢/kWh by 2005, 6¢/kWh by 2010, and down to 4¢/kWh by 2020.

FY 2001 Performance Measures

- # Evaluate the potential for small (1-5kW) dish-based systems to compete in green distributed markets before 2005.
- # Install and operate a 10kW off-grid dish/engine system on Native American land.
- # Develop advanced trough components used by U.S. trough team in competitive project bid.

FY 2002 - 2005 Performance Measures

- # Reduce installed costs below \$3,500/kW for dispatchable solar power systems.
- # Achieve 4,000 hours MTBF on dish/engine systems in field testing.

- # Incorporate latest R&D improvements into dispatchable power system to achieve first solar technology under 8¢/kWh.

Significant Accomplishments and Program Shifts

Pre-1999 Accomplishments

- # Achieved a 29.4% world record solar-to-AC-electric system conversion efficiency with the Advanco dish/Stirling system.
- # The ten-year-old Solar Electric Generating Systems (SEGS) trough plants, through improved O&M technologies and modest design upgrades, produce more energy annually today than when new, and continue to operate reliably.
- # The Solar Two power tower produced continuous power for 153 hours – energy from the sun alone, all day and all night, for nearly a solid week.

FY 1999 Major Accomplishments

- # *Solar Two Project:* Receiver modifications at Solar Two resolve last significant plant startup issues; plant operates smoothly through last day of operation, April 9, 1999.
- # *25 kW Utility-Scale Dish/engine Projects:* Accumulated over 2,000 hours of reliable operation - far exceeding 750 hour goal.
- # *10 kW Remote Power Solar Dish:* Completed system integration of state-of-the-art dish design; began on-grid on-sun testing at SunLab; issued competitive solicitation to 111 Indian tribes, anticipating multiple awards.
- # *USA Trough Initiative:* Competitive contracts underway for advanced trough component and system development activities; new cost-sharing industries involved.

FY 2000 Planned Accomplishments

- # Develop advanced trough concentrator with 20% lower cost than current SEGS technology.
- # Demonstrate fully autonomous operation and off-grid capability of a 10 kW dish/engine system; award siting and O&M contract to Native American tribe.
- # Award competitive contract(s) for the first conceptual design of small (1-5kW) dish-based systems.
- # Attain 4,000 hours total operation, establish 250 hour MTBF (mean time between failure) baseline on 25 kW utility-scale dish/engine systems.

FY 2001 Planned Accomplishments

- # Pursue advanced development under competitive USA Trough solicitation to improve component reliability.
- # Provide technical support to Global Environment Facility (GEF) trough project(s) with major U.S. industry participation.

- # Narrow field of small dish-based technology options; identify most viable systems for application in near-term distributed green power markets.

FY 2002 - FY 2005 Planned Accomplishments

- # Demonstrate viable thermal storage techniques for trough systems at existing plants.
- # Field-test dish/engine systems in a variety of user environments (e.g., utility end-of-line, land-fill gas sites, remote locations) accumulating in excess of 10,000 hours of on-sun operating data.
- # Scale-up and field-test advanced trough components capable of generating power under 8¢/kWh.

Program Completion

To serve initial high-value distributed power applications, the reliability of utility-scale dish/engine systems must be demonstrated. A principal focus of the CSP program over the next several years is to establish improved reliability, attaining 4,000 hours MTBF by mid-decade. At this level, industry can confidently pursue available market opportunities and deliver a system requiring only nominal maintenance support. A secondary issue is system cost, which is a function of both production level and component complexity. R&D will be conducted to simplify components and upgrade performance, and to streamline overall design to achieve a more readily assembled system. By 2005, the program will need to assess progress in these areas and, taking into account market levels attained by industry, determine type and extent of additional R&D support required, if any. The progress of the newer remote power solar dishes (10 kW) and the residential-size units (1-5 kW) will similarly be addressed at that time.

The Solar Two power tower successfully completed 3 years of operation in April 1999. Further progress in this area should follow from industry's pursuit of tower projects in response to the Spanish "Royal Decree". The current program focus in dispatchable power system development is to work with a resurgent U.S. trough industry to reduce component costs. These efforts are aimed at ensuring U.S. leadership in capturing project opportunities currently before the World Bank (\$50 million trough projects for Egypt and Morocco were approved in May 1999). Based on input from project developers, an important secondary issue is developing a near-term storage solution for troughs, using technology proven at Solar Two. The five-year goal of the program is to reduce delivered energy costs from the current 12¢/kWh to less than 8¢/kWh by 2005, at which point new domestic trough systems should begin to appear in selected high-electricity cost areas. Further federally-supported R&D will be required to reach the 4-6¢/kWh range and successfully penetrate broader markets.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Distributed Power System Development	5,300	5,155	4,300	-855	-16.6%
Dispatchable Power System Development	5,970	5,956	5,200	-756	-12.7%
Advanced Component and System Research	4,781	4,057	5,500	1,443	35.6%
Strategic Alliances and Market Awareness	740	0	0	0	0.0%
Total, Concentrating Solar Power Program	16,791	15,168	15,000	-168	-1.1%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Distributed Power System Development

<p># System Reliability – A key program thrust is to demonstrate reliable solar power systems able to compete in “green” distributed power markets by 2004. For utility-scale (25kW) dish/engine systems, design improvements from FY 2000 will be incorporated into a modernized system and operated to accumulate reliability data. For the remote power system, the off-grid capability and design improvements developed in FY 2000 will be incorporated in a next-generation unit which will be installed and operated on Native American land in FY 2001. In addition, in response to competitive solicitations issued in FY 2000, universities and private industry will be investigating the feasibility of small solar dish-based system designs. The decrease in funding reflects a shift in emphasis from capital intensive hardware development to reliability improvement..</p>			
	5,300	3,250	2,300
<p># System Testing and Field Validation – Funding will support the field validation and testing of four to six utility-scale dish/engine systems at user sites in Arizona and California. Incremental technology improvements will be integrated into prior systems to help achieve market-based reliability targets. This level of funding is needed to provide the required O&M and reliability system enhancements.</p>			
	0	1,905	2,000
Total, Distributed Power System Development.	5,300	5,155	4,300

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Dispatchable Power System Development

<p># Cost Reduction – A key thrust of the CSP Program is to develop advanced trough components that will serve expanding U.S. markets and give U.S. industry a leading role in GEF supported trough projects. FY 2001 work will focus on optimization of the collector design, improved system integration with conventional combined-cycle and heat-recovery plant layouts, and the evaluation of storage concepts. Additional activities include R&D on high-temperature systems and working fluids. Trough technology is currently in the 10-12¢/kWh range. Independent review boards, such as the President's Committee of Advisors on Science and Technology (PCAST), support this high-temperature work based on its potential of providing renewable power in the 4¢/kWh range. This funding decrease results from added emphasis on trough reliability issues.</p>			
	1,130	3,410	2,500
<p># System Testing and Field Validation – Technology validation is needed to guarantee the availability of reliable systems for use in near-term markets. FY 2001 work will include the field-testing of a new parabolic trough concentrator and an advanced trough receiver design. This funding increase results from component testing moving from the laboratory into the field.</p>			
	3,360	1,210	1,700
<p># Reliability and Lifetime Improvement – Cost-shared technical support was provided in FY 1999 to assist with the tracking and evaluation of trough components with special attention given to increasing the lifetime and maintainability of trough receiver tubes. In FY 2000, the Solar Two evaluation and lessons learned document will be completed. FY 2001 activities include advanced trough receiver development and work on field control systems and components, targeting reliability issues.</p>			
	1,480	1,336	1,000
Total, Dispatchable Power System Development.	5,970	5,956	5,200

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Advanced Components and Systems Research

- # **High Efficiency System Designs** – Activities include advanced research into high-efficiency system designs that will produce the long-term technological advances required for CSP to compete in both distributed and large-scale dispatchable power markets. Work will include advanced hybrid system designs for dish systems to enhance their dispatchability. The increased funding reflects an increase in hybrid solar/gas system research. This level of funding is required to pursue the most critical technology advances that will drive costs down and move CSP technologies closer to becoming a viable option for U.S. industry to meet the demand for clean power. 1,780 1,200 1,900
- # **System Analysis & Field Operations** – Funding supports the development of advanced communications and control systems, analysis tools, and system modeling. These funds also go to maintain the national laboratory facilities where much of the world-leading solar R&D is conducted. Activities include the development of direct-normal insolation (DNI) maps, technology roadmapping, technology characterization, and web-based communications which each serve as tools for project developers and researchers alike. The increase in funding level reflects the inclusion of DNI map activities. . . . 1,410 1,037 1,200
- # **Concentrators** – Project work will focus on the development of advanced reflective materials to enhance durability, structural facet design to lower the weight and cost of components, and advanced drives with mass-producible system designs. Wind load studies will also be conducted. This level of funding is required to accomplish the critical component R&D that will be incorporated in the next-generation systems. 1,220 1,220 1,600
- # **Long-Term R&D** – Program emphasis is on developing advanced CSP system designs with the reliability advantage of fewer moving parts, and provide an inroad into smaller residential markets where on-site power is in demand. Current projects include thermo-acoustic and concentrating solar thermo-photovoltaic technologies. FY 2001 activities will include the design of high-concentration photovoltaic systems

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
and alternate solar power conversion devices. This increase in funding will be needed to carry several of these advanced concepts through the design phase and into working prototypes of advanced CSP systems capable of achieving costs in the 4 to 6¢/kWh range.	371	600	800
Total, Advanced Component and System Research.	4,781	4,057	5,500
Strategic Alliances and Market Awareness			
# Funding in this area has supported technology transfer and market studies to ensure that the CSP Program is focused on the needs of industry and the realities of the marketplace. No funding is planned for FY 2000 or FY 2001.	740	0	0
Total, Strategic Alliances and Market Awareness.	740	0	0
Total, Concentrating Solar Power Program	16,791	15,168	15,000

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Distributed Power System Development

# System Reliability - Decrease reflects the transition from capital intensive hardware development to field testing for utility-scale dish/engine systems.	-950
# System Testing and Field Validation - Increase reflects the addition of several units to field validation activities offset by a decrease in O&M requirements..	95
Total Funding Changes, Distributed Power System Development	-855

Dispatchable Power System Development

# Cost Reduction - Decrease in funding results from added emphasis being given to trough system reliability issues.	-910
# System Testing and Field Validation - Increase due to the testing of advanced trough components moving from the laboratory into the field.	490

FY 2001 vs. FY 2000 (\$000)

# Reliability and Lifetime Improvement - Decrease due to the conclusion of Solar Two evaluation activities in FY 2000 offset by an increase in trough R&D to address reliability issues.	-336
Total Funding Change, Dispatchable Power System Development	-756
Advanced Component and System Research	
# High Efficiency System Designs - Increase in hybrid solar/gas system research to facilitate dispatchable solar power applications.	700
# System Analysis & Field Operations - Increase reflects additional funds for DNI solar map development and technology characterization work which support and validate the core R&D efforts.	163
# Concentrators - Modest increase for concentrator structural design improvements is needed to reduce support for advanced trough and dish mirror designs.	380
# Long-Term R&D - Increase for advanced power conversion systems in order to meet long-term cost goals.	200
Total Funding Change, Advanced Component and System Research	1,443
Total Funding Change, Concentrating Solar Power	-168

Biomass/Biofuels Energy Systems - Power Systems

Mission Supporting Goals and Objectives

Program Mission

The Biomass Power Systems Program (BioPower) mission is to integrate sustainable biomass feedstock production with efficient biomass power generation and thus enable biopower to be a major cost-competitive contributor to power supplies in both domestic and international energy markets.

BioPower systems generate electric power from resources such as energy crops, agricultural residues, wood, and wood residues. These can be co-fired with coal, burned directly as a single fuel in new power plants, or converted through a gasification process to a high energy gas steam to be burned in an advanced, high efficiency gas turbine to produce electricity. BioPower systems can also be integrated in industrial processes such as paper and allied products.

Program Goals and Objectives

By 2010, in collaboration with other government agencies, power producers, manufacturers, farmers, and foresters, the BioPower Program will have engaged in research and development activities to increase the viability of clean, efficient, biomass technologies for a variety of markets. This achievement will be signaled by the addition of 3,000 MW of new biomass power capacity in the U.S., increasing the total to 10,000 MW of domestic capacity. The program will benefit the American taxpayer by: helping to revitalize rural economies by providing jobs linked to biomass power production and co-products such as fuel, fiber, and feed; removing biomass residues from the waste stream; and improving the environment through reduction in greenhouse gas emissions.

BioPower Systems will be a major contributor toward meeting or exceeding the Solar and Renewable goal of doubling the renewable energy output by 2010. BioPower contributes to several of the objectives found within the Comprehensive National Energy Strategy and the goals of the International Clean Energy Initiative which involve the development of analytical tools for identifying opportunities for grid-connected and off-grid distributed systems in developing countries. The program requires private sector cost-sharing of 20-25 percent for R&D and feasibility studies, and 50 percent and higher in testing and demonstration projects.

Strategic Approach

Biomass is a local power solution with global implications. The BioPower Systems Program develops and validates the integration of clean, efficient, renewable, biomass-based electricity generation technologies with sustainable biomass supplies. There are three major energy technology areas of development: 1) co-firing biomass with fossil fuels such as coal and natural gas, 2) small modular biomass power systems and 3) advanced biomass gasification. The cofiring area has concentrated effort to demonstrate near-term benefits of modifying coal plants to allow 3% to 15 % of the fuel to come from

energy crops such as fast-growing willow trees and switchgrass and from other biomass resources such as wood residues. The Small Modular BioPower (SMB) Initiative will serve to bring viable biomass technologies into the global marketplace in the near term, e.g., systems less than 5MW. Advanced gasification technologies are beginning to achieve some R&D successes and will play a stronger role in the longer-term. In addition, cost-competitive feedstock development and resource assessment are indispensable components of an integrated national biomass strategy. Increasing yield and decreasing production costs are critical to the penetration of biomass into the marketplace.

During the 20th century, our nation's economy has depended heavily on imported fossil fuels. Biomass—a renewable alternative—represents a tremendous, untapped, domestic resource for our energy future. By investing in a bioenergy industry today, we can cultivate and harness these renewable resources to fuel our cars, power our homes and industries, and supply our chemical needs in the 21st century. The Administration, with DOE as a lead agency, is launching a national BioEnergy/Bioproducts Initiative to work with other Federal agencies and private sector partners to develop an integrated industry to produce power, fuels, and chemicals from crops, trees, and wastes. By making a “ton of biomass” a viable market competitor to a barrel of oil or a railroad car of coal, this initiative will help grow the U.S. economy, strengthen U.S. energy security, protect the environment, and revitalize rural America. This effort will integrate the work from existing DOE R&D in transportation biofuels, biopower and the biomass elements of Industries of the Future programs. It is only through the integration of these efforts that biomass will be an effective competitor to imported fossil fuels.

The BioPower Program is expanding its focus to include a full complement of efficient biomass technologies, size ranges, and feedstocks (agricultural residues, wood residues, energy crops, etc.). The program is working to balance the research and demonstration efforts to most effectively advance the technology. Toward this, we are asking for increased support for thermochemical conversion research over the five-year period as we maintain support for demonstration projects including co-firing and SMB. We think that additional simulations and performance modeling in the laboratory will allow us to save time and money during field demonstration projects. To take advantage of additional feedstocks, we are beginning the Agricultural Residues to Energy Initiative aimed at pairing animal producers, local energy producers (such as electric cooperatives), and state health, environmental and energy officials to develop projects which use animal manure or litter to produce power, making productive use of a potentially hazardous environmental pollutant. Increased focus on feedstock production, processing and handling is also necessary to advance biomass energy technology. The Bioenergy Feedstock Development Program is developing dedicated energy crops to ensure that there will be widespread availability of cost-competitive, environmentally-acceptable, feedstock technologies.

The BioPower Program will also support the International Clean Energy Initiative effort to optimize the mix of renewables based on local resources in developing countries by using distributed grid-connected systems with biomass, PV and wind, and off-grid/mini-grids. In addition, a Carbon Savings Initiative will be developed to increase the net energy output of biopower systems per unit of carbon used.

We remain committed to forging partnerships with other Federal agencies, communities, power generators, manufacturers, farmers and foresters to fully demonstrate sustainability of clean, renewable, biomass power. As several of the technologies proceed along a development path, the Federal dollars help to reduce the risk that pioneer developers and power producers experience when initially using a new technology. Without the encouragement and support of the BioPower Systems Program, it is unlikely that clean and efficient biomass power would be produced in significant quantities.

Program Benefits

Metrics	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.19	0.50	0.83
Energy Savings (\$ Billions)	0.08	0.18	0.32
Carbon Displaced (MMTCE)	4.42	11.70	17.43

The primary energy displaced in 2010 will be enough to power 4.5 million U.S. homes and 5.7 million homes in 2020. The carbon reductions achieved are equivalent to removing 8.9 million vehicles from U.S. highways by 2010 and 11 million vehicles by 2020 (8% of today's U.S. vehicles). Co-firing technology has the potential to replace at least 8 GW of the nation's coal-based capacity by 2010, as much as 26 GW by 2020. The benefits of cofiring include carbon savings, SO_x reduction, and NO_x reduction. By 2002, the original group of Biomass Power for Rural Development projects will have been completed, bringing to commercial readiness in excess of 50 MW of biopower. By 2020, over 10 million acres of energy crops could be in place, supporting over 260,000 U.S. jobs.

Gasification technologies have the potential to produce electricity at up to twice the efficiency of direct-fired biomass systems. The development of gasification technologies are anticipated to provide up to 22 GW of power over the next two decades. Implementing biomass Integrated Gasification Combined Cycle (IGCC) systems into existing paper mills alone could potentially double power production efficiency. Full industrial implementation, involving the replacement of all black liquor and biomass boilers with gasification technology, would diminish carbon emissions by 40-60 million metric tons per year. Emissions reduction of NO_x, volatile organic compounds (VOCs) and particulates would also be significantly reduced. Other benefits include: increased biopower generating capacity (25-30 GW), improved operational safety, improved capital effectiveness, and chemical consumption reductions.

Animal residues represent about 0.25 quads of usable primary energy. The program will facilitate using 5% of this energy by 2005, 25% by 2010, and 75% by 2020. At a 70% capacity factor, this will represent 0.16 GW in 2005, 0.55 GW in 2010, and 2.3 GW in 2020.

Performance Measures

Metrics	FY 2000	FY 2010	FY 2020
Co-firing System Payback (in years) ¹	6.2	3.9	3.6
Co-firing Availability ²	81%	90%	95%
Gasification COE (1997¢/kWh) ³	6.9	6.1	5.4

¹ The number of years required to pay back the capital investment in a co-firing retrofit.

² Fraction of time a generating unit is able to supply power at various capacity levels. The availability of a co-firing system refers to the fraction of time the biomass receiving, processing, storage, handling, and fuel injection systems are functioning to allow co-firing.

- ³ Cost of electricity is a common utility industry metric for evaluating alternatives for new generating capacity. Values are in constant 1997 dollars (expressed as cents).

FY 2001 Performance Measures

- # Thermochemical Conversion: Complete integrated testing of gasification/internal combustion system for a small modular system making a medium calorific value biogas.
- # Carbon Savings Initiative: Issue feasibility study request for proposal for ultra-high efficiency systems and mineral carbon sequestration.
- # Cofiring with Coal Initiative: Initiate testing of one cofiring system. Two additional projects will have completed testing and be at the point of operational readiness.
- # Biomass Power for Rural Development: A second commercial-scale cofiring test for switchgrass in Iowa will be completed.
- # Vermont Gasification: Successfully complete shake-down testing of integrating gasification to combustion turbine.
- # Agricultural Residues to Energy: Complete 4–8 Phase 1 feasibility studies.
- # Small Modular Systems Development: Complete prototype operation of systems selected for Phase II of this initiative.
- # International Clean Energy Initiative: Grid-Connected Systems: Evaluate the cost effectiveness of distributed grid-connected biomass systems (including biochemical and thermochemical [gasification] coproduct systems at 1 site).
- # International Clean Energy Initiative: Off-Grid/Mini-Grids: Demonstrate small-scale biomass in hybrid applications in 1 multi-country region.
- # Feedstock Development: Complete the development of 2 high-yield woody biomass crop clones and release them to nurseries. Begin materials handling initiative.
- # Regional Biomass Energy Program: Complete Agriculture Residues Inventory.

FY 2002 - 2007 Performance Measures

- # Develop and demonstrate high yield short rotation plants and grasses for biomass power uses, for instance, successful high yield varieties of willows, poplars, and switchgrass. In excess of 5,000 new acres of different high-yielding varieties will be planted by the private sector and used in power applications.
- # Generate 2 GWe (0.05 Quads/y) from biomass and coal cofiring, offsetting 4 million metric tons of fossil carbon per year.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- # Conducted critical and pioneering applied research, pilot testing, and feasibility studies in the areas of biomass combustion and biomass gasification, which provided the foundation for advanced and improved technology development.
- # Successfully demonstrated sustained operation of the Battelle/FERCO advanced biomass gasifier in Burlington, Vermont, at the McNeil Biomass Power Station.
- # Initiated co-firing demonstrations with modifications started at two power stations.
- # Completed feasibility studies for ten diverse small modular systems.

FY 1999 Accomplishments

- # Completed parametric testing of the Vermont gasifier.
- # Completed design of power plant modifications for cofiring of biomass with coal activities.
- # Completed the Phase I feasibility studies for the Small Modular BioPower initiative.
- # Competitively selected small modular systems for Phase II, prototype testing and demonstration.
- # Initiated additional cofiring demonstrations in collaboration with EPRI and FETC.
- # Completed life cycle analyses quantifying the environmental performance and benefits of existing biomass plant technology and gasifier-cofiring system.

FY 2000 Planned Accomplishments

- # Complete the power plant retrofit for cofiring with coal in Chariton Valley and the Salix Consortium Rural Development projects.
- # Complete resource database for biomass crops and residues.
- # Complete laboratory testing of 2 types of engines coupled with the lab-scale biomass gasifier.
- # The BioPower Systems Program will successfully complete engineering, installation and commissioning of the catalytic gas conditioning and compression system at Vermont's biomass gasification facility through partnerships with the private sector. Long-term operational testing of the gasifier will provide the forest products industry with performance data for implementation of these systems in that sector.
- # Successful completion of the NIPSCO Bailly Cofiring demonstration will facilitate diffusion of biomass and coal cofiring throughout the industry.

FY 2001 Planned Accomplishments

- # Complete the prototype testing phase of the Small Modular Systems Initiative.
- # Begin the final phase, Phase III, the commercial demonstration of the two to three most promising Small Modular Systems Initiative projects.

- # Complete the development of 2 high yield woody biomass crop clones and release them to nurseries.
- # Initiate focused effort for development of advanced modeling tools in support of the bioenergy industry and to foster improved process integration and reduced technology development time and cost.
- # Complete integrated testing of gasification/internal combustion system for a small modular system making a medium calorific value biogas.
- # Initiate commercial testing of one gasification-based cofiring process.
- # Complete two additional cofiring projects to the point of commercial readiness.
- # Successfully demonstrate sustained operation of the total Vermont biomass system (gasifier, gas clean up, and biogas combustion turbine).
- # Complete 4–8 Phase 1 feasibility studies for the Agricultural Residues to Energy initiative.
- # Complete the development of 2 high-yield woody biomass crop clones and release them to nurseries.

FY 2002 - 2007 Planned Accomplishments

- # Complete the Small Modular Systems Initiative with two to three small-scale biomass systems poised for rapid commercialization by the private sector.
- # Complete all three Biomass Power for Rural Development projects with more than 100MW of new biomass power generating capacity.
- # Complete development of 3 high-yield willow clones which increase yields by at least 20%.
- # Complete the Co-firing Initiative with new facilities that were in the partnership. Facilities are cofiring biomass on a regular basis.
- # Operate five or more successful demonstration projects with animal manure as a fuel for electricity production as part of the Cooperative Agricultural Residues to Energy Initiative.

Program Completion

Completion of the program is anticipated for 2010, depending on the state of adoption of the technology. Modest support for research and development to further increase efficiency and decrease emissions from costs of biomass power plants may be important beyond this time frame.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Thermochemical Conversion	1,550	1,700	5,000	3,300	194.1%
Systems Development	25,716	23,035	26,400	3,365	14.6%
Feedstock Production	2,300	3,100	4,000	900	29.0%
Regional Biomass Energy Program	1,250	1,000	1,600	600	60.0%
Bioenergy/Bioproducts Initiative	0	3,000	11,000	8,000	266.7%
Total, Biomass/Biofuels Energy Systems - Power Systems	30,816	31,835	48,000	16,165	50.8%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Thermochemical Conversion

- # **Thermochemical Conversion** - Includes systems integration research using NREL's Thermal Conversion User facility, cofiring and ash deposition studies, systems analysis and modeling, component testing, and capital equipment. This funding supports research on gas treatment/cleanup options and integration for small and large biopower systems; research to minimize the impacts of contaminants such as alkalis, chlorine, and nitrogen that cause operational or emissions problems in biopower systems; technical assessments and modeling of the dynamics of operational systems and the environmental life cycle impacts of technology options; technical support of large demonstration projects such as the Vermont project; and testing of components of small modular systems. An increase is needed to initiate dynamic modeling of advanced gasification processes. 1,550 1,700 3,500
- # **Carbon Savings Initiative** - A new initiative will be established to increase the net energy output of biopower systems per unit of carbon used. The initiative will be carried out through a multi-phase competitive solicitation process,

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
starting with feasibility studies, and proceeding through proof of concept prototypes to demonstration units. There are two areas of interest: a) combined heat and power systems which have at least a 40% biomass-to-electricity efficiency, and an overall process efficiency of 90%, and b) bio-electric systems that incorporate mineral-based carbon getters to sequester in mineral from at least 50% of the biomass carbon on a full fuel life cycle basis; and that have overall process efficiencies greater than 40%. Research will investigate which mineral forms are able to absorb carbon under the right conditions as the use of limestone in power plants to absorb other emissions such as sulfur dioxide actually releases carbon dioxide. The increase represents the cost of starting the Request for Proposal (RFP) process and funding the initial phase of selected projects.	0	0	1,500
Total, Thermochemical Conversion.	1,550	1,700	5,000

Systems Development

# Cofiring with Coal Initiative - Cost-shared projects include those being conducted by TVA, NIPSCO, GPU, New York State Electric and Gas, Southern Companies, and Central and Southwest. Ongoing support to the initiative will also request expanded technical and financial cost-shared assistance to utility and non-utility producers of electric power that utilize coal as a primary fuel. Initiative will be expanded to include a greater percentage of Investor-Owned Power Producers, Municipals, Cooperatives, and Federal Utilities, and Non-Utility Generators (includes Colleges and Universities). Efforts will include elimination of technical barriers to biomass feedstock handling, transport, and integration into coal fired systems, defining combustion characteristics and emission profiles and deposition phenomena. The Cofiring Initiative is increased by \$2,400,000 to support projects requiring higher capital investment levels such as gasification-based cofiring. Projects are supported at the 50 percent cost-share level. . . .	1,866	7,000	9,400
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(dollars in thousands)

	FY 1999	FY 2000	FY 2001
# Biomass Power for Rural Development - This initiative includes the New York Willow project that will produce 30-40MW of capacity through cofired applications, and the Iowa Switchgrass project that will utilize up to 36,000 acres of switchgrass dedicated to co-firing operations. Due to unforeseen State regulatory impediments and pricing structure barriers encountered by Minnesota Alfalfa Valley Producers and its development partners, Federal support for this project has been concluded. The decrease in funding represents the conclusion of the support for the MnVAP project that lowers funding by \$14,250,000.	15,450	4,000	4,000
# Vermont Gasification - This effort focuses on the demonstration of biomass gasification integrated combined cycle technology in a utility setting. The purpose is to demonstrate commercial-scale, indirect gasification technology that will allow gasification to be integrated with electric generation technology. The project will validate the performance and economic viability of the Battelle Memorial Institute gasification technology. Hot gas clean-up technology will be demonstrated along with the completion of 1,000 hours of operation. This will be accomplished at double the efficiency of direct-fired biomass units. Decreased funding levels are requested due to anticipated lower equipment costs.	3,000	5,000	4,000
# Agricultural Residues to Energy - The project is needed to resolve environmental problems with animal waste while converting the material to a productive energy resource. This effort will be closely coordinated with EPA and USDA. The first year of the initiative we anticipate a competitive solicitation for feasibility studies. Historical funding levels have been comparable for similar feasibility solicitations. . .	0	0	1,500
# Small Modular Biopower Initiative -This activity will develop modular biopower systems that are fuel flexible, efficient, simple to operate, whose operation has minimum negative impacts on the environment, and will provide power in the 5 kW to 5 MW size range for domestic and international markets. This effort will continue to build on developments achieved in prior years through laboratory			

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
research and will be closely coordinated with the EPA. Industry cost-shared efforts will focus on technical and economic feasibility of several system configurations that include both advanced combustion and gasification systems for distributed generation and remote applications.	2,000	4,620	5,500
# International Clean Energy Initiative - Grid-Connected Systems: Evaluate the cost effectiveness of distributed grid- connected biomass systems (including biochemical and thermochemical [gasification] coproduct systems at 1 site. Off Grid/Mini Grids: Demonstrate small-scale biomass in hybrid applications in 1 multi-country region. Analytical tools will be developed for identifying and evaluating developing country opportunities for distributed grid-connected biomass (including biochemical and thermochemical coproduct systems) and off grid/mini-grids by using small scale biomass in hybrid systems with fossil and other resources where appropriate. International equipment standards that assist open competition will be developed. All funds will be competitively awarded.	0	0	2,000
# Other - FY 2000 funding is designated for the Michigan Biotechnology Institute (\$1,449,000) and the Consortium for Plant Biotechnology Research (\$966,000).	3,400	2,415	0
Total, Systems Development.	25,716	23,035	26,400

Feedstock Production

# Feedstock Development Base Program - Research is being conducted to improve yields and reduce handling costs of herbaceous and woody crops that can be produced on American farms. Federal support is needed to facilitate the widespread availability of biomass at scales capable of supporting multiple bioenergy and bioproducts industries. These herbaceous and woody crops will be produced on American farms and comprise a sustainable, cost-competitive, dedicated resource for bioenergy production.	2,300	3,100	2,000
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(dollars in thousands)

	FY 1999	FY 2000	FY 2001
# Soil and Climate Variability - Assess the effects of variability in soil type and climate on feedstock characteristics relevant to combustion and gasification systems and on soil carbon sequestration processes, as well as yield variability. Feedstock characteristics and chemical composition can greatly influence performance and conversion efficiencies of these thermochemical processes. Funding levels are required to fund four or five university-conducted applied studies. . . .	0	0	1,000
# Integrated Bioenergy Systems Modeling - Initiate efforts to create tools of evaluating the viability of multiple bioenergy technologies, with an emphasis on biopower technologies, and their impact on feedstock demand. Establish a consistent methodology and modeling framework for linking existing models for feedstock collection/production and delivery costs with models for bioenergy conversion processes so that power generation costs and carbon offset contributions can be evaluated. Only through full integration of biomass production/harvesting/conversion/power generation can the technical and economic benefits of biomass power systems be realized.	0	0	1,000
Total, Feedstock Production.	2,300	3,100	4,000

Regional Biomass Energy Program

# Regional Biomass Energy Program - Activities will include sponsoring National biomass conventions, sponsoring grants to State Energy Offices and local industries for biomass power projects as well as to complete the integration of biomass resource assessments.	1,250	1,000	1,600
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Bioenergy/Bioproductions Initiative

Bioenergy/Bioproductions Initiative – In FY 1999, the President signed Executive Order 13134 and the Memorandum on Promoting Biobased Products and Bioenergy. In FY 2000, an Interagency Council and

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Advisory Committee will be formed to coordinate programs within agencies and build upon their expertise. The Advisory Committee will be tasked with completing a strategic plan for the Bioenergy/Bioproducts Industries. In addition, an industry supported vision and road-mapping effort will identify high priority technologies and processes needed to reach the goals of this initiative. To support these efforts, competitive solicitations will be conducted at the Department for integrated R&D, analysis, and education. A fundamental goal of these solicitations will be to perform research and development that results in integrated co-products addressing at least two of the three major areas of chemicals, fuel, and/or power, where power can be electricity and/or heat.

For FY 2001, efforts will follow the new strategic plan and roadmaps identified under the Bioenergy/Bioproducts Initiative that utilizes biomass to advance both an integrated bioenergy industry, as well as its renewable bioproducts industry sector. Building upon the success of the FY 2000 competitive solicitations, the FY 2001 larger effort is being planned to include more targeted solicitations aimed at gaps identified in the strategic plan. It is anticipated that new partnerships will come together for the first time in an integrated fashion, leading to new business opportunities. Innovative approaches will be encouraged through a multi-agency, industry peer view project selection process.

Achieving the President's recently announced goal of tripling the use of bioenergy and bioproducts would create \$15 billion to \$20 billion in new income for farmers and rural communities and cut back on the use of imported oil. Greater integration of government and industry efforts will lay the groundwork for the rapid growth of this industry for the next century.

0 3,000 11,000

Total, Biomass/Biofuels Energy Systems - Power Systems.

30,816	31,835	48,000
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Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Thermochemical Conversion

# Thermochemical Conversion - The use of advanced modeling techniques such as computational fluid dynamics has saved millions of dollars in the development of advanced cooling techniques and low-NO _x combustors in the gas turbine industry and in the design of advanced boilers. Demonstration, testing and equipment redesign that would otherwise be required has either been eliminated or the number of evolutionary steps significantly reduced. This increase is necessary to bring biomass system modeling to the state-of-the-art to offer significant reductions in the development costs of bioenergy technologies and systems.		1,800
# Carbon Savings Initiative - This increase is necessary to start a new initiative to increase the net energy output of biopower systems per unit of carbon used through high efficiency power and thermal recovery systems and through development of mineral-based carbon getters.		1,500
Total Funding Change, Thermochemical Conversion		3,300

Systems Development

# Co-firing with Coal Initiative - An increase in the Cofiring Initiative is to support industry cost-shared projects that eliminate technical barriers to biomass feedstock handling, transport, and integration into coal fired systems; definition of combustion characteristics, emission profiles and deposition phenomena; and gasification-based cofiring.		2,400
# Vermont Gasification - The Vermont project decreases because of anticipated lower equipment costs.		-1,000
# Agriculture Residues to Energy - This new initiative is to develop projects which use animal manure or litter to produce power.		1,500
# Small Modular Biopower Initiative - The system development increases due to added labor costs for prototype testing in Phase 2 and a small expansion of DOE/EPA collaborative effort.		880
# International Clean Energy Initiative - A new effort has begun to develop grid-systems and off-grid/mini-grid systems with biomass and other renewables.		2,000

FY 2001 vs. FY 2000 (\$000)

# Other - Activities decrease due to completion of support for the Michigan Biotechnology Institute and Consortium for Plant Biotechnology Research, Inc. . .	-2,415
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Total Funding Change, Systems Development	3,365
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Feedstock Production

# This increase is primarily to fund an assessment of the effects of variability in soil type and climate on feedstock characteristics relevant to combustion and gasification systems and on soil carbon sequestration processes, as well as yield variability. Additionally, a consistent integrated modeling framework for BioPower generation costs and carbon offsets will be established	900
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Regional Biomass Energy Program

# This increase is for additional sponsoring grants to State Energy Offices and local industries for biomass power projects as well as to complete the integration of biomass resource assessments.	600
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Bioenergy/Bioproducts Initiative

# Efforts will follow the new strategic plan and roadmaps identified under the Bioenergy/Bioproducts Initiative that utilizes biomass to advance both an integrated bioenergy industry, as well as its renewable bioproducts industry sector. Building upon the success of the FY 2000 competitive solicitations, the FY 2001 larger effort is being planned to include more targeted solicitations aimed at gaps identified in the strategic plan. It is anticipated that new partnerships will come together for the first time in an integrated fashion, leading to new business opportunities. Innovative approaches will be encouraged through a multi-agency, industry peer view project selection process.	8,000
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Total Funding Change, Biomass/Biofuels Energy Systems - Power Systems	16,165
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Biomass/Biofuels Energy Systems - Transportation

Mission Supporting Goals and Objectives

Program Mission

The Energy Information Administration (EIA) forecasts that, by 2020, U.S. petroleum imports of 10 million barrels per day will increase to 16 million barrels per day, 64 percent of the projected use. Ethanol and other biofuels can be produced domestically from renewable resources.

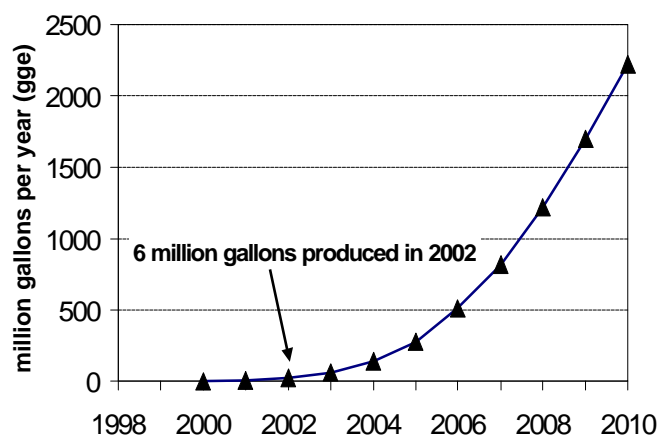
The mission of the Biofuels Energy System–Transportation program, managed by the Office of Energy Efficiency and Renewable Energy’s Office of Transportation Technologies, is to research, develop, and demonstrate cost competitive technologies for the production of liquid fuels and co-products, in partnership with industry, other government organizations, academic institutions, and others.

Program Goals and Objectives

The 2010 goal is to increase domestic cellulosic ethanol production to 2.2 billion gallons (from zero in 2000). For the ethanol program, production cost goals have been established. The goals provide the direction for the research and development activities supported by the program. By the year 2002, the goal is to demonstrate that ethanol production costs are competitive in the oxygenate market using low cost biomass. Highly leveraged partnerships to build ethanol demonstration facilities have been established with at least 80 percent private sector investment. Additional partnerships will be established that will lead to the construction of cellulose-to-ethanol facilities. By the year 2004, at least two ethanol facilities will be in operation using biomass wastes, and a partnership with the corn ethanol industry will complete testing of ethanol production from corn stover. These partnerships are essential components for achieving our programmatic goals.

The year 2005 goal is to validate fermentation technology capable of economically producing ethanol from energy crops such as switchgrass. Since energy crop technologies complement various end use applications, funds are requested by both Biomass/Biofuels Energy Systems-Transportation and Biomass/Biofuels Energy Systems-Power Systems. Transportation’s intent is to develop and demonstrate technologies capable of producing ethanol such that, by 2010, the U.S. average production cost is \$1.02 per gallon at the ethanol plant gate, before including distribution, retail markup and incentives.

Domestic Cellulosic Ethanol Production



The program is also exploring opportunities to produce renewable products for heavy vehicle use, specifically renewable alternatives to the diesel fuel pool, including biobased lubricants. Activities include research to lower the costs of biodiesel and the testing and development of new fuel formulations for heavy vehicle use. Niche opportunities for biodiesel are available in environmentally sensitive areas, such as underground mining, marine, and fragile ecosystems (e.g., National Parks).

Strategic Approach

The program supports the development of biomass feedstocks and technologies for liquid fuels production from these feedstocks. Feedstocks include agricultural residues from harvesting operations (corn, wheat, rice, etc.), forest wastes/residues (excess growth, dead trees, etc.), and energy crops, i.e., trees and grasses grown specifically for use as energy feedstocks.

To accomplish the program's cost goals and proceed beyond the first demonstration facilities, research, development and demonstration activities are conducted in accordance with integrated biomass feedstock and conversion systems. Energy cropping systems using the best varieties and management practices must be developed through breeding and field testing across a wide range of sites and conditions in the different growing regions. Once developed, these systems will be capable of providing reliable biomass supplies. Recent success in the Northwest obtained biomass production levels of over five times that of natural systems.

The key to producing ethanol competitively is cost-effective technology for breaking down cellulose to simple sugars. Low cost sugars could also be used to manufacture chemicals and other high value co-products. For example, the sugars could be converted to succinic acid, which can be used directly or as an intermediate in producing plastics, clothing fibers, paints, inks, and other products. The foundation for the conversion research program is a strong core of research and development for the production of ethanol and co-products, including chemicals and electricity. Core R&D emphasizes pretreatment, cellulase (enzymes) development, and fermentation organism development as the key features of second generation technology, and is expected to result in higher reaction rates, yields, fewer process steps, reduced raw material input, and other improvements. In addition, the program supports the integration and demonstration of near-term technologies to produce ethanol and co-products at industrial facilities.

The President's Bioenergy Executive Order established the policy of this Administration "to develop a comprehensive national strategy, including research, development and private sector incentives, to stimulate the creation and early adoption of technologies needed to make biobased products and bioenergy cost-competitive in large national and international markets." The President's Order provides the leadership and impetus for the Department of Energy to continue its efforts to grow an integrated industry to produce fuels, power, and chemicals from crops, trees, and wastes. By making a "ton of biomass" a viable market competitor to a barrel of oil or a railroad car of coal, this initiative will help increase the growth of the U.S. economy, strengthen U.S. energy security, protect the environment, and revitalize rural America. This Bioenergy/Biobased Products Initiative will integrate the work from existing DOE R&D in transportation biofuels, biomass power and the Forest Products and Agriculture Industries of the Future programs to enable technologies that produce different combinations of fuels, power, chemicals and other products from different feedstocks in different areas of the country. It is only through the integration of these efforts that biomass will be an effective competitor to imported fossil

fuels. The initiative will be implemented through competitive solicitations, based on technology roadmaps.

A strong Biofuels program is consistent with the recommendations of many internal and external studies that have examined various DOE programs, including the PCAST report, and reports on actions to reduce global warming. The goals and strategies are also consistent with the various levels of DOE strategic planning.

Partnerships with industry will be essential for establishing a bio-ethanol industry. Demonstration projects require at least 50% private sector cost share. R&D projects require at least 20% private sector cost share. Approximately \$11 million will be provided to partnerships in 2001.

The program plans to take advantage of current opportunities such as the phase out of MTBE in California and potential restrictions in the Northeast that have created a tremendous opportunity for ethanol. The program works closely with the California Energy Commission through an EERE Memorandum of Understanding to determine areas of mutual interests, including co-funding of mutually beneficial projects and activities. The potential for an increased share of the oxygenate market, coupled with Congressional support that led to the passage of the extension of the ethanol tax incentive, provide a unique “window of opportunity” for the deployment of cellulosic ethanol technology.

The Regional Biomass Energy Program (RBEP), funded as a part of the Transportation program (with additional funds being requested by the Biomass Power program in the Office of Power Technologies) plays a significant role in coordinating and leveraging the Federal investment with State and local governments in technology deployment. RBEP, through its local and regional contacts, transfers current and reliable information on biomass development activities to potential users. This includes economic and technical information, as well as State and local regulatory, environmental, and market considerations related to the production of fuels, chemicals, and electricity.

Program Benefits

Metrics	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.02	0.18	0.68
Energy Cost Savings (\$ Billions)	0.00	0.01	0.13
Carbon Displaced (MMTCE)	0.44	3.43	12.86
Oil Displacement (million barrels per day)	0.01	0.09	0.32

Performance Measures

FY 2001 Performance Measures

Deliver to industrial partner an arabinose fermenting yeast.

FY 2002 Performance Measures

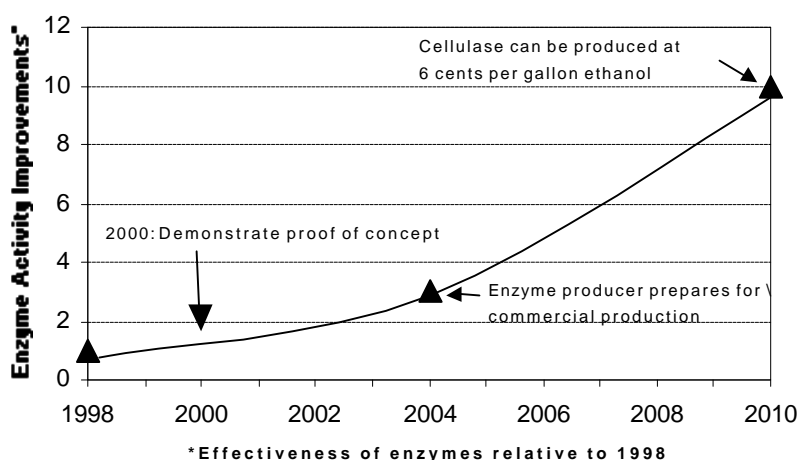
- # Existing industry partner (not corn processing company) completes construction of commercial plant for ethanol production using biomass other than corn residues.

FY 2003 Performance Measures

- # Complete establishment of 12 on-farm, field scale (10-20 acres) switch grass plantings across Nebraska, North Dakota and South Dakota, documenting establishment practices and costs.

FY 2004 Performance Measures

Cellulase Enzyme Development



- # Enzyme activity is increased by a factor of 3 relative to 1998 *T. reesei* cellulase demonstrated in the laboratory. By 2004, the enzyme industry will be ready for commercial production to supply biomass conversion plants (see Figure).

FY 2005 Performance Measures

- # Second generation fermenting micro-organism is available for developmental testing.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- # The use of corn ethanol in blends (as of 1998) has displaced 10 billion gallons of gasoline and reduced carbon emissions by 6.5 million metric tons since 1982. The alternative fuels program that was started in 1975 was partly responsible for the original research results that allowed and encouraged the use of ethanol blends.
- # Received the prestigious R&D 100 award for developing *Zymomonas mobilis*, a fermentation organism capable of converting 30% of available sugars to ethanol. (1995)

- # Successfully operated the process development unit in an integrated continuous mode with an industry partner at the National Renewable Energy Laboratory's Alternative Fuels User Facility. (1996)
- # Developed hybrid poplar clones in the feedstock development activity, which were planted commercially by industry on over 75,000 acres in the Pacific Northwest. (1997)
- # Established a partnership with BC International for the first domestic biomass ethanol production facility in Louisiana. (1997)
- # Completed bench-scale development and formed a partnership for converting softwoods to ethanol using dilute acid hydrolysis. (1998)
- # Expanded switchgrass breeding activities and initiated testing on a 20-acre research site to validate the yield and cost of switchgrass production. (1998)
- # Completed bench- and pilot-scale testing to convert sugarcane bagasse residue to ethanol. (1998)

FY 1999 Accomplishments

- # In collaboration with timber industry, United States Forest Service, and local communities, completed a study of the hydrologic effects resulting from the removal of forest thinnings.
- # Completed bench scale testing to convert softwoods to ethanol.
- # In partnership with USDA, expanded economic model for energy crops to include idled land, crop land pasture, and land in the Conservation Reserve Program.
- # Completed competitive solicitations in the areas of enzymes, fermentation, innovative technologies for ethanol production, biomass resource assessment, and feasibility of adding cellulosic feedstock to corn ethanol plants.
- # Completed one feasibility study to add cellulosic feedstock at a corn ethanol plant.

FY 2000 Planned Accomplishments

- # In collaboration with industry partners, complete engineering feasibility study to produce ethanol from softwoods that are representative of those growing in Alaska.
- # Release new/improved hybrid poplar clones for public use.
- # Establish partnership for R&D of harvesting, handling and storage alternatives for agricultural residues, such as corn stover.
- # In collaboration with other EERE bio-energy programs, complete road map for Integrated Bio-Energy Research and Development, and conduct solicitation for related activities.
- # Demonstrate conversion of agricultural wastes to ethanol at a small commercial scale using a genetically engineered fermentation microorganism.

FY 2001 Planned Accomplishments

- # Conduct competitive solicitation and select at least one partner for demonstrating the conversion of cellulosic feedstock at a corn ethanol plant.

Finalize experimental plan for conversion of agricultural residue to ethanol.

FY 2002 - 2006 Planned Accomplishments

- # Complete construction of municipal solid waste-to-ethanol plant. (2002)
- # Complete pilot-scale testing of softwood conversion to ethanol and electricity. (2003)
- # Complete pilot-scale testing of residue conversion in cooperation with corn ethanol industry. (2004)
- # Complete bench-scale testing of fermentation organism for energy crop conversion. (2005)
- # Complete revised conceptual design of enzymatic hydrolysis plant for ethanol production, integrating co-products. (2006)

Program Completion

The program is anticipated to be completed in 2015, depending on the state of adoption of the technology. Modest support for research and development to further increase process efficiencies and reduce costs of producing biofuels from energy crops for transportation purposes may be required beyond this time frame.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Ethanol Production	35,436	30,142	38,441	8,299	27.5%
Renewable Diesel Alternatives	750	750	1,000	250	33.3%
Feedstock Production	2,800	3,000	4,500	1,500	50.0%
Regional Biomass Energy Program	2,250	2,000	3,500	1,500	75.0%
Bioenergy/Bioproductions Initiative	0	3,000	7,000	4,000	133.3%
Total, Biomass/Biofuels Energy Systems - Transportation	41,236	38,892	54,441	15,549	40.0%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Ethanol Production

- | | | | |
|--|-------|-------|-------|
| <p># Advanced Fermentation Organisms R&D - Organisms will be developed with increased stability, robustness, and ability to ferment mixed sugars from waste feedstocks and the energy crop, switchgrass, to lower the cost of ethanol production from biomass. To achieve further cost reduction, research and development of advanced (second generation) organisms will be pursued. The goal is to ferment additional sugars with greater efficiencies at higher temperatures and expand biomass ethanol applications. (FY 2000 and FY 2001) This funding level is considered appropriate based on extensive experience with laboratory and pilot scale operations and personnel costs.</p> | 2,200 | 3,347 | 4,500 |
| <p># Advanced Cellulase R&D - Analyses indicate that the production of ethanol, using enzymes for the breakdown of biomass materials to sugars for fermentation, is limited to a great degree by the high cost of enzymes. Research and development partnerships with enzyme producers will be established to provide more productive, lower cost cellulase systems. Partnerships with enzyme and biomass ethanol producers will be developed to accelerate the use of commercially-available cellulase systems. Research for advanced (second generation) cellulases will be initiated. The funding level was determined based on cellulase colloquies with industrial experts, and potential cost-sharing and program reviews..</p> | 4,147 | 4,722 | 7,500 |
| <p># Pretreatment R&D - Appropriate physical and/or chemical pretreatment of biomass facilitates enzyme and fermentation reactions, thereby improving process efficiency and lowering costs.</p> | | | |

In FY 2000, shakedown of the countercurrent pretreatment reactor system will be completed and testing will be initiated. Testing of the reactor will be completed and an industrial collaboration will be pursued for commercial demonstration in FY 2001, if economic goals are met. The evaluation of novel pretreatment systems will continue and a process simulation

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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model will be developed. Funding level is considered appropriate based on experience with operations and personnel costs, and cost-sharing by industry partner.

2,800 3,323 4,441

- # **Consortium for Plant Biotechnology Research** - Seventeen grants were competitively awarded to University Consortium members in FY 1998, and fifteen awards were made in FY 1999 for basic research. The 50:50 cost-shared, long term R&D projects with The Consortium for Plant Biotechnology Research, Inc., (CPBR) for peer-reviewed, basic university research will not be continued in order to focus on more applied research activities that support program goals and objectives.

1,250 0 0

- # **Integrated Process Development** - In FY 1999, integrated bench-scale studies evaluated the overall process and performance of softwood thinnings from private and public forests, including National Forests, in cooperation with industrial partners. Technologies for the coproduction of ethanol and other high value products will be researched and developed by the Michigan Biotechnology Institute (MBI). DOE provided \$3,000,000 to MBI in FY 1999. For FY 2000, an additional \$1,500,000 was appropriated by Congress.

Integrated bench-scale and pilot-scale testing of the overall process (handling, pretreatment, fermentation) will continue to evaluate performance, efficiency, and costs for conversion of agricultural waste feedstocks, such as rice straw. Softwood feedstocks, such as thinnings from private and public forests, will be tested at the NREL Biofuels User Facility/Process Development Unit, in support of commercial partners considering the production of ethanol and integrated co-products. Analytical studies will assess the process economic goals. Funding is considered appropriate based on standard cost-estimating practices implemented and validated at the laboratory (operations and personnel costs).

11,500 11,000 11,000

- # **Cellulose to Ethanol Production Facilities** – The Biofuels program is laying the groundwork for a broad-based biomass to ethanol industry through cost-shared partnerships to design and construct ethanol demonstration facilities. In FY 1997, DOE entered into a partnership with BC International (BCI) to

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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demonstrate BCI's technology at the BCI Jennings, LA project. DOE's biofuels contribution totaled \$16.5 million (FY97-\$2.0 million, FY98-\$4.0 million, FY99-\$5.0 million, and FY 2000 \$5.5 million) of an estimated total project cost of \$120 million. DOE is making the final contribution in FY 2000. In FY 1999, DOE made a one-time \$4.0m contribution toward Arkenol's Rio Linda, California facility.

Also, in collaboration with the California Energy Commission, the Biofuels program is supporting the development of various projects in Northern California using a variety of agricultural and forestry residues for the production of ethanol and high value chemicals. In FY 1999, the Department entered into a collaborative effort with the Alaska State Energy Office and Sealaska Corporation to initiate the development of an ethanol production facility in southeastern Alaska. In the Midwest, DOE is supporting the development of partnerships with existing corn ethanol producers to demonstrate the conversion of corn stalks to ethanol. Funding support for these efforts is continuing in FY 2000.

In FY 2001, a competitive solicitation will be conducted to support the integration of cellulosic conversion processes with existing corn ethanol facilities and power generation facilities. Funding level is considered appropriate, providing minimum cost-share in some cases (20% or less) by DOE, and is based on prior experience with these types of partnerships.

	13,539	7,750	11,000
Total, Ethanol Production.	35,436	30,142	38,441

Renewable Diesel Alternatives (Formerly Biodiesel Production)

- # Based on a technoeconomic assessment, research and development will improve biodiesel process technology, using waste grease streams to lower production costs. Promising alternatives for the diesel fuel pool, including renewable additives and lubricants, will be identified. Research will be conducted to lower cost, and testing will determine performance characteristics. Working with industry, activities to identify markets will continue. Funding level is considered

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
appropriate and depends on cost-sharing to be successful. Research and development costs are based on work involved and personnel requirements.	750	750	1,000
Total, Renewable Diesel Alternatives.	750	750	1,000

Feedstock Production

# Biomass Feedstock Development Centers - Research and development will be conducted on economically viable model energy crops at integrated biomass feedstock development centers in the Southeast (switchgrass), Midwest/Plains States (switchgrass and poplars) and Northeast/Lake States (willow). At these centers, breeding to select for higher yields and other desirable traits is linked closely with studies on management, physiology, growth-limiting factors, and advanced biotechnology. Field studies to evaluate nutrient effects on carbon sequestration and storage will be added to provide additional vital information on energy crops. Funding level determined from prior experience with work involved and makes use of experts at universities and U.S. Department of Agriculture over four regions of the U.S.	1,600	1,900	3,200
# Environmental Effects of Energy Crop Deployment - Research to evaluate the effects of large scale deployment of energy crops on the environment, such as water and soil quality, chemical fates, and biodiversity will provide credible data that can be used to guide deployment in a manner that ensures energy and environmental benefits. Funding level is considered appropriate based on the level of effort which makes use of existing field sites.	225	225	225
# Energy Crop Seedling/Planting Stock Selection Research - Advanced biotechnology and other methods will develop techniques that can be used to select energy crop seedlings or other planting stocks that are less susceptible to disease and/or pests, reducing the risk of mortality and increasing technical/economic viability. Desirable genotypes of switchgrass will be selected, propagated, and transferred to greenhouse/field tests to verify the selection process. Funding level is based on level of effort for this university project.	100	100	100

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
# Large Scale Woody Crop Plantation Research - Research will be conducted to develop and evaluate management techniques to overcome the water use efficiency constraints in the Southeast. Technical assistance and cost sharing will be provided for existing large scale plantings in the Midwest/North Central region, to obtain feedstock performance and cost data. Funding level was determined from level of effort needed to provide technical assistance by a laboratory expert for these large scale plantings and expectation of low level cost share.	125	125	125
# Switchgrass Variety Testing and Scale-up Research - Switchgrass variety field tests are being conducted in the major growing regions of the U.S. Field trials established at five USDA National Plant Materials Testing Centers will evaluate newly developed switchgrass lines. Cost-shared 100-300 acre scale-up plantings of switchgrass will be evaluated to provide yield, operational issues, and cost data. Field tests and scale-up data will be collected and evaluated and field trials near waste-to-ethanol facilities/sites will be established. Funding level is considered appropriate based on level of effort, work scope, and use of university and U.S. Department of Agriculture expertise and facilities.	500	250	400
# Feedstock Composition and Multi Product Use - Altering plant composition to improve conversion efficiencies will provide potential benefits and cost reductions in the production of fuels, chemicals and electricity. The tailoring of plants so that all components of the plant can be used effectively to produce multiple products will provide potential cost reductions and broader opportunities for adaptation of feedstock production systems. Plant biotechnology research will be initiated, based on co-product potentials and strategies identified in FY 1999. Funding level is appropriate considering the work scope involved.	100	200	200
# Mechanization Research - Mechanization systems for energy crops, to lower harvesting/handling costs, will address a major obstacle to the widespread use of energy crops. Cost-shared opportunities for switchgrass handling and storage, specifically as a means of improving the ethanol production costs, will be explored. Handling and storage systems for the			

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
use of agricultural residues to produce ethanol will be evaluated to improve costs and process efficiencies. Funding level is determined by work scope and cost share requirements.	150	200	250
Total, Feedstock Production.	2,800	3,000	4,500

Regional Biomass Energy Program

# Regionally-focused activities with State and local governments, in partnership with industry, will further develop the capability to produce and use biomass resources for multiple products. Using the regional program infrastructure, support will be provided for cost-shared site studies for biofuels production facilities, including resource assessments and analyses of local, State, and regional nontechnical issues. Funding level is determined based on extensive prior experience with this activity and cost share requirements.	1,650	1,400	2,000
# The potential of biodiesel will be improved by testing new biodiesel fuel formulations to enhance fuel performance of high efficiency engines, in collaboration with the Office of Heavy Vehicle Technologies in the Office of Transportation Technologies, USDA, and the National Biodiesel Board. Funding level is considered appropriate based on work scope and prior experience in this activity plus cost share.	600	600	1,500
Total, Regional Biomass Energy Program.	2,250	2,000	3,500

Bioenergy/Bioproductions Initiative

In FY 1999, the President signed Executive Order 13134 and the Memorandum on Promoting Biobased Products and Bioenergy. In FY 2000, an Interagency Council and the Advisory Committee is being formed to coordinate programs across agencies and build upon their expertise. The Advisory Committee will be tasked with completing a strategic plan for the Bioenergy/Bioproductions Industries. In addition an industry supported vision and road-mapping effort will identify high

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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priority technologies and processes needed to reach the goals of this initiative. To support these efforts, competitive solicitations will be conducted at the Department for integrated R&D, analysis, and education. A fundamental goal of these solicitations will be to perform research and development that results in integrated co-products addressing at least two of the three major areas of chemicals, fuel, and/or power, where power can be electricity and/or heat.

For FY 2001, efforts will follow the new strategic plan and roadmaps identified under the Bioenergy/Bioproducts Initiative that utilizes biomass to advance both an integrated bioenergy industry, as well as its renewable bioproducts industry sector. Building upon the success of the FY 2000 competitive solicitations, the FY 2001 larger effort is being planned to include more targeted solicitations aimed at gaps identified in the strategic plan. It is anticipated that new partnerships will come together for the first time in an integrated fashion, leading to new business opportunities. Innovative approaches will be encouraged through a multi-agency, industry peer review project selection process.

Achieving the President's recently announced goal of tripling the use of bioenergy and bioproducts would create \$15 billion to \$20 billion in new income for farmers and rural communities and cut back on the use of imported oil. Greater integration of government and industry efforts will lay the groundwork for the rapid growth of this industry for the next century.

0 3,000 7,000

Total, Biofuels Energy Systems	41,236	38,892	54,441
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Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Ethanol Production

# Advanced Fermentation Organisms R&D - Conduct advanced (2 nd generation) fermentation organism R&D that can ferment biomass feedstocks with high efficiency at higher temperatures.	1,153
# Advanced Cellulose R&D - Increase support for cellulase research to reduce costs in this critical area.	2,778
# Pretreatment R&D - Increase support for pretreatment R&D to a level consistent with testing and evaluation of novel pretreatment systems.	1,118
# Cellulose to Ethanol Production Facilities - Increase support for industrial partnerships resulting from a competitive solicitation for cellulosic biomass technology integrated with existing corn ethanol facilities.	3,250
Total, Ethanol Production.	8,299

Renewable Diesel Alternative

# Increase support of renewable diesel alternatives to lower the production costs of promising alternatives for the diesel fuel pool.	250
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Feedstock Production

# Biomass Feedstock Development Center - Increase support of Biomass Feedstock Development Center in the Upper Plains States and incorporate carbon sequestration and storage research to determine potential of energy cropping systems.	1,300
# Switchgrass Variety Testing and Scale-up Research - Increase support of switchgrass variety field test on sites typical of major growing regions of the U.S.	150
# Mechanization Research - Increase support to evaluate handling and storage systems leading to improved costs and efficiency of agricultural residue use.	50
Total, Feedstock Production.	1,500

FY 2001 vs. FY 2000 (\$000)

Regional Biomass Energy Program

# Increase support for site specific studies and analyses of nontechnical issues relative to the increased use of biomass based products.	600
# Increase support to test new renewable fuel formulations to enhance fuel performance of high efficiency engines.	900
Total, Regional Energy Biomass Program.	1,500

Bioenergy/Bioproductions Initiative

# Increase support for R&D competitive solicitation to develop inexpensive cellulase systems, to develop “leap frog” technologies for converting biomass into high value bioproducts, and to promote integrated biomass gasification systems with modern gas-turbine/steam-turbine generation systems.	4,000
Total Funding Change, Biofuels Energy Systems	15,549

Wind Energy Systems

Mission Supporting Goals and Objectives

Program Mission

The mission of the Wind Energy Systems Program is to help the United States attain the substantial economic, environmental, and energy security benefits of expanding the domestic and worldwide use of wind energy, and of fostering a world-class, domestic wind energy industry. The Program focuses on completing the research, testing, and field verification needed by U.S. industry to fully develop advanced wind energy technologies, and on coordinating with partners and stakeholders to overcome barriers to wind energy use.

Program Goals and Objectives

The Wind Program has established the following goals as measures of success in accomplishing its mission:

- # Next generation wind turbines from U.S. companies capable of achieving a cost of energy of 2 ½ cents/kwh at 15 mph wind sites by 2002.
- # 100 MW of wind generating capacity used for distributed power or off-grid applications in the United States by 2005.
- # 10,000 MW of total wind generating capacity in the United States by 2010 (approximately 2,500 MW on-line at the end of 1999).

These goals are directly supportive of broader Departmental strategic plans and objectives. The year 2010 capacity goal is a key contribution to realizing the Department's Comprehensive National Energy Strategy goal to achieve 25,000 MW of non-hydroelectric renewable generating capacity by 2010. Without the wind energy contribution of 10,000 MW by 2010 supported by the Wind Program's proposed strategy, this objective is not likely to be achieved. Wind capacity additions provide an energy security benefit since the resource is indigenous and renewable. Wind energy capacity additions make significant contributions responding to environmental objectives such as global climate change mitigation and clean air by displacing emissions from fossil-fueled electric generation sources. National economic development objectives are supported by increasing the United States' share of the rapidly growing global market for wind energy systems.

Strategic Approach

In 1999, close to 5 billion kilowatt-hours of electricity were produced by wind turbines in the United States, enough to meet the electricity needs of nearly 500,000 U.S. households. Total worldwide installed wind generating capacity now exceeds 13,000 MW, and annual industry sales are approaching \$4 billion. Wind energy has been the fastest growing source of energy in the world over the last decade, increasing at an average rate of over 25% per year, a trend driven largely by dramatic improvements in wind energy technology. As a result, numerous organizations including the Royal Dutch Shell Group, the World Energy Council, and the European Commission have issued statements affirming a strong future for wind energy. The growth in wind energy use will displace airborne emissions, increase energy security, and provide economic growth opportunities throughout the world.

Installation of wind power stations in Europe and developing countries has accounted for most of the recent worldwide capacity increase, with wind turbines supplied primarily by European companies. Wind power development in the United States is beginning to recover from several years of stagnation, with over 1000 MW installed in 1998 and 1999. However, the future of wind energy in the United States is still highly uncertain as electric power markets deregulate and increase emphasis on low cost of energy production. Continued wind energy technology development is needed to close the cost gap between wind and fossil power generation to assure the viability of wind energy in new competitive power markets, and to allow U.S. technology to compete overseas.

The DOE Wind Program has been increasingly successful in improving the performance and decreasing the cost of wind systems and subsequently enhancing its commercial prospects. Today, in areas with ideal wind resources, electricity can be produced for less than \$0.05 per kilowatt-hour compared to wind energy in 1980 at \$0.35 per kilowatt-hour - a decrease of 85 percent in just 15 years. Recent partnerships with DOE have produced 3 commercially-offered wind turbines, with another 5 now under development.



Remote Community Power

The DOE Wind Energy Program supported the design and installation of a 660 kW wind energy project for the Kotzebue Electric Association in Kotzebue, Alaska. The 66 kW Atlantic Orient Corporation Model 15/50 wind turbines used in this project were designed with assistance from the Wind Energy Program for use in cold weather and other challenging environments. Kotzebue's wind turbines are producing electricity for approximately 13 cents per kWh. Local diesel generation, which is environmentally hazardous and difficult to maintain, is expensive in comparison, costing approximately 20 cents per kWh. As Alaska phases out State subsidies derived from declining North Slope oil production, communities such as Kotzebue are faced with rising electricity costs, as well as the environmental risk of using diesel fuel in fragile ecosystems. The Kotzebue project is a model for other Alaskan and remote communities seeking to relieve their dependence on diesel power systems.

The challenge for the Wind Program is to assist industry in bringing the cost of wind technology to a level where it can compete with traditional energy sources. The program conducts R&D with significant cost-sharing through industry partnerships and collaboratives. Partners working collaboratively with DOE include the wind and electric utility industries, National Laboratories (National Renewable Energy Laboratory [NREL], Sandia National Laboratory [Sandia]), and universities.

The Wind Program strategy for continuing the rapid advancement of wind energy technology focuses on the following thrusts:

On going Activities:

- ▶ **Applied Research** - The objective of Applied Research is to develop cutting edge tools and concepts for wind energy system design efforts, technologies to expand wind energy applications, and strategies to assure cost-effective wind plant operation. This activity provides the fundamental technological underpinnings needed to support the Program's partnerships with industry for advanced technology R&D. Outcome from core research activities is being carried further through R&D partnerships between government and industry to develop and test innovative components and subsystems for use in new turbine designs. The WindPACT (Wind Partnerships for Advanced Component Technologies) project initiated in FY 2000 continues U.S. technological improvement beyond the next-generation turbines to pave the way for further U.S. technology cost reductions.
- ▶ **Turbine Research** - The role of the Turbine Research activity is to provide an opportunity for U.S. industry to apply the technology breakthroughs and design tools from Applied Research in developing advanced technology wind turbines. This role is implemented through the close partnerships between the Wind Program's National Laboratories and U.S. companies via competitively awarded, cost-shared subcontracts, typically with 20% to 30% industry share. Wind turbines resulting from projects under Turbine Research are critical to fulfilling the Program's cost of energy and domestic capacity goals.
- ▶ **Cooperative Research and Testing** - Cooperative Research and Testing activities support the domestic and international competitiveness of wind energy equipment and services offered by U.S. firms. Under this activity the Wind Program assists in the development, testing, and analysis of solutions to the industry's current operational challenges. The Wind Program will continue to focus on enhancing U.S. wind turbine certification capabilities and ensuring that U.S. industry can meet certification requirements of many worldwide market opportunities for wind energy on a level playing field with foreign competition.

New Activities and Initiatives:

- ▶ **Wind Powering America** - Wind Powering America is a national commitment to dramatically increase the use of wind energy in the United States, with a long-term goal of supplying 5% of the Nation's electricity needs in 2020 from wind. Wind energy technology is now recognized as an important opportunity to provide sustainable income for American farmers and other rural landowners, and help meet the Nation's growing demand for electricity from clean resources. Through Wind Powering America, the United States will achieve targeted regional economic development, protect the local environment, displace airborne emissions and lessen the risks of global climate change, increase energy security and maintain international competitiveness in the

growing international market for clean energy technologies. This initiative will provide national leadership, coordination, and support for voluntary stakeholder partnerships of regional, state, and organizations from both the private and public sectors, representing all elements of the supplier, user and environmental communities.

- ▶ **Regional Field Verification** - Field verification is an essential component of the R&D cycle, and also assures performance is proven to investors and financiers. New competitively selected projects under Regional Field Verification will validate advanced wind turbines in several regions of the nation, each with unique considerations for wind power development. Also, because the use of wind turbines in combination with diesel generators and other renewables and storage systems is a potentially major market for U.S. technology, new technologies enabling use of wind energy in hybrid power systems will be verified in remote applications. The financial resources required to complete field verification of advanced technology wind turbine and hybrids systems have been well beyond what the U.S. wind industry could afford during times of stagnant and uncertain domestic markets.
- ▶ **Advanced Turbine Concepts** - Over the past several years, foreign wind turbine development efforts have increasingly focused on machines in the multi-megawatt range to achieve economies of scale, more effective land utilization, and improved cost effectiveness, particularly for offshore applications. The Wind Program is launching the Advanced Turbine Concepts project to encourage industry to first carefully assess the prudence of moving toward larger-scale or other advanced concept turbine architectures, and then examine technology issues such as design tools needed, manufacturability, and transportability. The results of these studies would provide the basis for focused R&D support from the laboratories and possible future partnerships with industry.
- ▶ **International Clean Energy Initiative** - The President's Committee of Advisors on Science and Technology (PCAST) strongly recommends that the United States play a leadership role in international cooperation on clean energy technologies to address critical environmental and economic concerns with current world energy development trends. The Wind Program is proposing two new program activities to pursue promising opportunities for wind energy to help fulfill the objectives of the International Clean Energy Initiative. Analytical efforts will be undertaken as the first step toward development and verification of technologies and operating strategies to maximize the benefits of grid-connected, distributed wind power projects, which are expected to be the prevalent mode for wind energy use in developing countries. For remote off-grid and mini-grid applications, the Wind Program will support opportunities for U.S. companies to gain field verification experience with advanced wind hybrid power system technologies.

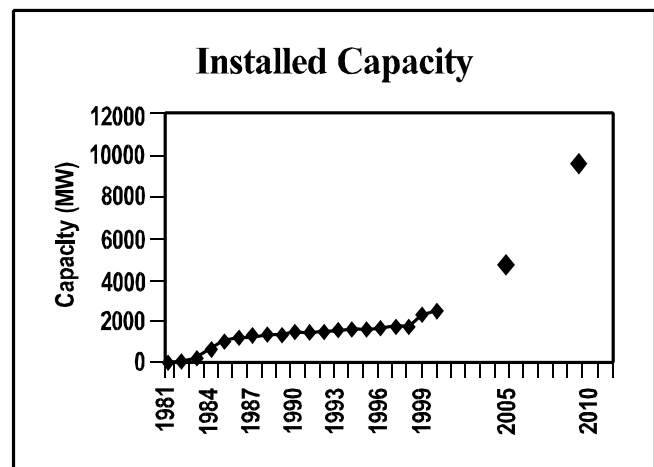
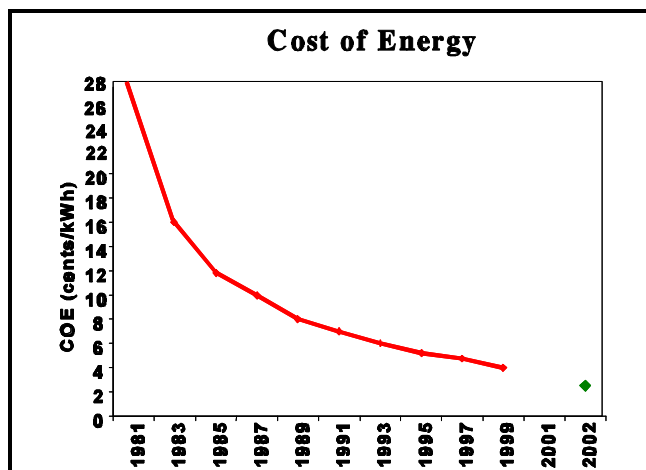
Program Benefits

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.25	0.59	1.23
Energy Savings (\$ Billions)	0.55	1.47	2.80
Carbon Displaced (MMTCE)	4.81	10.79	22.24

The annual amount of energy generated from wind in the United States in 2000 will be equivalent to the annual electricity needs of over 500,000 average U.S. households.

Performance Measures

The following charts depict the historical performance of wind technology relative to the Program's key goals.



FY 2001 Performance Measures

- # Two new small wind turbines and a cold weather turbine will be commercially introduced by U.S. companies.
- # State-of-the-art aerodynamics models will be validated using data from full-scale wind turbine tests in the NASA Ames 80 by 120 foot wind tunnel.
- # Advanced wind hybrid control system technology developed jointly with the USDA Agricultural Research Center will be commercially available.
- # 3000 MW of domestic wind generating capacity will be operating.

FY 2002 - 2006 Performance Measures

- # Next generation turbines, capable of producing electricity at \$0.025/kWh at 15 mph wind sites, will begin operating.
- # Prototype testing of 2-3 innovative component technology concepts under WindPACT will demonstrate potential for an additional 20% cost of energy reduction beyond Next Generation technology.
- # 5000 MW of domestic wind generating capacity will be operating by 2005.

Significant Accomplishments and Program Shifts

Metric	1999 Benefits	Cumulative Benefits 1995-end of 1999
Primary Energy Displaced (Quads)0034	.011
Energy Savings (1997 \$ billions)004	.013
Carbon Reduction (million metric tons equivalent)069	.22

Pre-FY 1999 Accomplishments

- # Advanced airfoils developed by the Wind Program have been adopted in three commercially available U.S. wind turbines, resulting in an increase in efficiency of up to 30% compared with previously available blade designs. Several computational codes that are key to wind turbine design are now available or improved as a result of the Program's core R&D efforts.
- # Zond Energy Systems' emergence as the leading wind turbine manufacturer in the United States followed successful collaborative efforts with Wind Program through ongoing Turbine Research and Turbine Verification Program partnerships begun in 1993. Zond, the turbine manufacturing subsidiary of Enron Wind Corporation, publicly recognizes the critical Wind Program's technical contributions to the success of their wind turbine technology.
- # Obtained National Wind Technology Center accreditation for performing certification testing in compliance with International Standards Organization (ISO) requirements.
- # Initiated two new cost-shared projects with host utilities for field verification of advanced wind turbine technologies.

FY 1999 Accomplishments

- # Established Underwriters Laboratories as the first U.S.-based wind turbine certification agent.
- # Completed validation of advanced wind turbine design codes for application to extremely lightweight, flexible designs.
- # Completed installation of a prototype 750KW wind turbine under Near Term Research and Testing project, and began field testing.

- # Competitively selected ten distributed power field verification projects using smaller ($\leq 50\text{kW}$) wind turbines.
- # Completed installation of seven additional 50kW wind turbines for the Kotzebue, Alaska wind project.

FY 2000 Planned Accomplishments

- # Install and begin testing two proof-of-concept turbines under Next Generation Turbine project leading to commercial availability of technology capable of producing electricity at 2 ½ cents per kWh in 15 mph in by 2003.
- # Install a prototype 100 kW cold weather wind turbine at the National Wind Technology Center (NWTC) for certification and long-term reliability testing.
- # Complete testing of the highly instrumented aerodynamics research turbine, previously tested at the NWTC, in the NASA Ames Research Center's 80 by 120 foot wind tunnel to establish steady inflow baseline performance data.
- # Install two prototypes for field testing under the Small Wind Turbine project.
- # Complete Near Term Research and Testing project.
- # Complete first year of operation of five distributed power field verification projects using smaller ($\leq 50\text{kW}$) wind turbines.
- # Utility-scale wind farms will be operating in eight additional U.S. states, compared to five at the beginning of 1998.

FY 2001 Planned Accomplishments

- # Complete prototype testing of a 100 kW cold weather turbine at the NWTC and in Kotzebue, Alaska.
- # Complete three-year operating and data collection period for initial Turbine Verification Program projects in Texas and Vermont, and issue final reports.
- # Competitively select 2-3 partners for advanced hybrid system technology field verification projects under Hybrid Systems for Village Power.
- # Competitively select 2-3 partners for performing data collection, analysis, and eventual field verification projects under Distributed Wind Power.

FY 2002 - 2004 Planned Accomplishments

- # By 2002, at least one regional wind monitoring network will be in operation.
- # By 2003, install an additional 1½ MW of wind power to complete the Kotzebue, Alaska wind project.

Program Completion

The ultimate success of the wind program depends on the ability of wind energy to penetrate the conventional power system. The continuing drop in fossil fuel costs implies that the cost of wind energy must still fall further to achieve a fully competitive level. The Program is committed to work in partnership with industry to conduct the R&D needed to continue to reduce wind energy costs. By 2006, the Program expects to begin shifting from an active partnership with industry for technology development to a strategy of supporting cross-cutting research that is beyond the capabilities of individual firms or industry consortia.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Applied Research	10,700	13,500	15,000	1,500	11.1%
Turbine Research	15,815	12,500	14,500	2,000	16.0%
Cooperative Research and Testing	7,561	6,481	21,000	14,519	224.0%
Total, Wind Energy Systems	34,076	32,481	50,500	18,019	55.5%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Applied Research

Core Research - The Core Research element of Applied Research advances the U.S. wind energy technology base through research, testing, and analysis focusing on the complexities of wind and how it interacts with wind turbine rotors; how wind turbine structures and materials react and withstand the forces of wind over time; and how all parts of wind energy systems - blades, drivetrains, generators, power convertors, control systems, and towers - can be optimized for cost effectiveness and reliability. These efforts culminate in computational codes for wind turbine design, identification and verification of improved wind turbine design features, and input into the development process for international consensus standards on wind

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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turbine design. Field testing will be conducted at the National Wind Technology Center and at the USDA Agricultural Research Facility in Bushland, Texas to further understanding of ambient inflow, turbulence, complex terrain, and rotor dynamics. The funding level requested is based on historical experience in planning and managing numerous core research projects. The funding increase supports development of aerodynamics, load prediction, and inflow models needed by industry to develop larger-scale machines, and provides support for participation in the international standards development process.

8,200 8,500 8,600

WindPACT - Promising research ideas and concepts generated in Applied Research Activities will be further developed and tested by a joint team of industry and laboratory researchers under the Wind Partnerships for Advanced Component Technologies (WindPACT) project. Two to three competitively selected R&D subcontracts will explore concepts such as light-weight and direct-drive generators; flexible and articulated rotors; feedback controls for load alleviation; and high efficiency power converters. WindPACT provides a mechanism for transfer of technology from the Program's core research activities to industry, beyond what will occur in the next-generation turbine efforts. The funding increase will accelerate completion of first phase concept development activities, enable earlier initiation of prototype fabrication and testing, and allow for soliciting partners for 1-2 additional technology concepts. .

0 2,500 3,500

University Research - The Wind Program relies on universities (including Historically Black Colleges and Universities (HBCUs) and Hispanic Educational Industries) to provide new theories and concepts for improved wind technologies. The funding increase is required to support a new competitive solicitation for HBCUs.

1,100 1,000 1,200

Wind Hybrid Systems Research - Applied Research also includes R&D for technologies that enable wind to be used in stand-alone, hybrid power systems. The major research issue is design of a control system to allow the diesels to be

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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turned off when possible to reduce overall consumption of diesel fuel. In addition to control systems R&D, the Program is supporting a control system field verification project in Alaska, with approximately 60% of project funding provided by sources other than the Department. The increased funding level is based on the anticipated laboratory in-house, consultant, and hardware costs for testing and validation of new supervisory control systems and evaluation of the effects of system architecture on performance and cost effectiveness. The funding will also continue support of hybrid wind projects in Alaska, and evaluation of commercial control systems at the NWTC hybrid power test bed and at the USDA research facility in Bushland, Texas. The requested increase reflects anticipated costs for supporting these planned activities. . .

1,100	1,000	1,200
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Avian Research - Avian concerns can pose a significant challenge to siting and operation of wind turbines. For this reason, continued research is needed to identify mitigation measures that would reduce adverse impacts that might otherwise occur, and to provide guidance for appropriate siting of wind facilities. The requested funding level is based on requirements for supporting laboratory in-house costs, and continuation of a subcontracted control study of avian impacts at an operating wind facility.

300	500	500
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Total, Applied Research.

10,700	13,500	15,000
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Turbine Research

Next Generation Turbine - The Next Generation Turbine project is the Wind Program's primary investment in achieving a cost of energy from wind of \$0.025/kWh by 2002. This project is focused on completing research and development with two industry partners leading to state-of-the-art utility scale (500kW - 2MW) wind turbines. Requested funding is based on projected spending for the two cost-shared industry subcontracts (30% industry share), and will support final design and fabrication of engineering and manufacturing development turbines.

3,015	5,600	6,700
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(dollars in thousands)

	FY 1999	FY 2000	FY 2001
# Near Term Research and Testing - Conduct Near Term Research and Testing project to support U.S. industry in reducing costs, enhancing reliability, and obtaining certification for wind turbines targeted for near-term markets. Field testing of a 750 kW prototype turbine is being completed in FY 2000, and no further funding is required for completion of the project.	3,675	1,100	0
# Small Wind Turbine - Conduct Small Wind Turbine projects to assist U.S. industry in research and development of wind turbines in the 8-40 kW range for stand-alone, remote, hybrid, and home/farm power applications. The funding level supports completion of field testing for two small wind turbine prototypes.	625	500	300
# Advanced Turbine Concepts - Solicit concept studies from industry to evaluate U.S. prospects for large scale, multi-megawatt wind turbines and other innovative wind turbine architectures. Studies will examine market and technology issues and help determine whether the U.S. industry should be moving toward multi-megawatt wind turbines as the Europeans are, and whether innovations hold potential for significantly improving cost effectiveness. The funding requested is based on the anticipated costs of at least three industry studies, and costs for laboratory in-house management and technical support.	0	0	1,500
# Cold Weather Turbine - The Wind Program will take the lead in completing prototype development, testing, and field verification for the Cold Weather Turbine project, targeted for locations such as Alaska and the South Pole, as the third phase of a Small Business Innovation Research effort begun by the National Science Foundation and the National Aeronautics and Space Administration. The project will employ direct-drive generator technology developed under the Wind Program's Next Generation Innovative Subsystems projects, completed in FY 1999. The requested funding level is reduced in accordance with anticipated costs for completing field testing at the National Wind Technology Center and a location in Alaska.	300	800	100

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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# Supporting Research and Testing - The supporting research and testing (SR&T) element of Turbine Research assures that industry's wind turbine R&D efforts take full advantage of the Wind Program's technology developments, and provides resources to conduct testing and analysis otherwise unavailable to industry. In addition, SR&T includes technical support for the Turbine Verification Program, which is helping the wind industry and utilities gain valuable field experience with advanced technologies in several projects across the Nation. Funding requested for supporting research and testing is based on previous experience with the level of support needed for Turbine Research and Turbine Verification Program activities. The funding will support design review, analysis and testing services needed for several on-going Turbine Research subcontracts with industry. Technical and data analysis support will be continued for five ongoing Turbine Verification Program projects.			
	8,200	4,500	5,900
Total, Turbine Research.	15,815	12,500	14,500

Cooperative Research and Testing

Wind Powering America - Support Wind Powering America, a new nationally-led program to accelerate use of wind energy in the United States. Funding will support a regionally-based program to coordinate and implement tailored strategies to help each region of the Nation benefit from harnessing their wind power resources. Regional efforts will facilitate partnerships among key stakeholders, including Federal, state and local offices, utilities, farmers and rural landowners, Native American groups, and the wind industry. The Wind Program will provide technical and funding resources for activities such as wind mapping, transmission and utility systems studies, targeted technical assistance, and development of education and outreach programs. Activities to increase use of wind energy by Federal facilities will also be supported. Educational efforts will include a competitive program with universities to

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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encourage renewable energy use, including wind, and the development of curricula-based materials for use in primary and secondary schools.

0 0 5,000

Industry Support - Cooperative Research and Testing will provide support to the U.S. wind industry, focused through the National Wind Technology Center, in resolving near-term technical problems and providing technical support for competing in world markets. The requested funding level is based on past experience in the level of support needed to complete activities that assist the U.S. wind industry in resolving near-term technical problems and enhancing technology transfer, providing technical support for the U.S. manufacturers competing in world markets, and supporting domestic field verification projects such as the Navy wind project on San Clemente Island, with estimated cost-sharing of 50%.

1,535 3,181 3,000

Regional Field Verification - Competitive solicitations will be issued in key regions for wind power development in the United States to support projects addressing unique siting, regulatory, electric power system, and market issues in each region. The use of wind power in central station generation, distributed power, and off-grid or minigrid applications will be targeted. The funding requested is based on anticipated first year costs to support 3-5 projects ranging from 500 kW to 25 MW or more, with Federal cost sharing of 15 to 25%, and to provide for laboratory in-house technical support. . .

0 0 5,000

International Clean Energy Initiative - Wind energy can play a vital role in meeting growing needs in developing countries for both distributed, grid-connected power and remote off-grid and mini-grid power. For distributed wind power applications, 2-3 competitively-awarded partnerships will be established with industry for analyses of distributed wind in weak grid applications, and to explore opportunities to enhance these applications through wind energy forecasting, grid control, storage options, and/or firming with natural gas or other generation sources. For remote power needs, the Wind Program will support U.S.

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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industry's need to obtain essential field verification experience with advanced wind hybrid power system technologies. Two to four industry partners will be competitively selected for wind hybrid system verification projects in developing countries where local utilities or villages currently use stand-alone diesel power systems. The funding level is consistent with the Wind Program's previous experience with similar analytical activities and hybrid systems field verification projects

0 0 4,000

Certification - Continue support for further development of wind turbine certification capabilities in the United States. The National Wind Technology Center will continue efforts to develop capabilities and attain accreditation for all six critical tests required for certification to international standards. The requested funding is based on anticipated laboratory in-house costs, consulting and equipment costs for continued certification program development and testing for the newly established U.S. based wind turbine certification agent, Underwriters Laboratories.

3,361 800 800

Utility Analysis - Continue support for analytical efforts to address wind energy power system integration issues. Initiate the Wind Performance Monitoring Network to verify data on long term performance of new wind projects, especially concerning ancillary service requirements. This information will be instrumental in devising strategies to accelerate the use of wind energy by wind developers, power marketers, renewable and other power aggregators and power system operators. The Wind Performance Monitoring Network is vital to the overall Wind Program effort to study and understand the integration of wind energy into electric power systems to facilitate utility sector acceptance. The requested funding level is based on experience with laboratory in-house costs for on-going studies, and anticipated costs for establishing the wind monitoring network.

1,465 1,300 2,000

National Wind Technology Center Operations - Continue operation of the National Wind Technology Center operations to maintain world class research and

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
testing capabilities and facilities for the U.S. wind industry. The requested funding level is based on requirements for laboratory site support staff, contractors and equipment. . .	1,200	1,200	1,200
Total, Cooperative Research and Testing.	7,561	6,481	21,000
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Total, Wind Energy Systems.	34,076	32,481	50,500

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Applied Research

# Core Research - Improve turbine design codes and international standards for larger-scale wind turbines.	100
# WindPACT - Accelerate concept development and fabrication of prototype components.	1,000
# University Research - Solicit new HBCU research projects for advanced wind energy system concept studies.	200
# Wind Hybrid Systems Research - Expand hybrid control systems research and testing effort to accelerate introduction of advanced technologies for remote applications.	200
Total Funding Change, Applied Research.	1,500

Turbine Research

# Next Generation Turbine - Funding increase to support major hardware acquisition to fabricate engineering and manufacturing development prototypes. . .	1,100
# Near Term Research and Testing - No further funding required for project completion.	-1,100
# Small Wind Turbine - Reduced funding supports completion of field testing for two small wind turbine prototypes.	-200

FY 2001 vs. FY 2000 (\$000)

# Advanced Turbine Concepts - Anticipated costs for three new industry studies and associated laboratory in-house costs to examine larger scale and other advanced wind technology concepts.	1,500
# Cold Weather Turbine - Funding reduced in accordance with needs for completing field testing.. . . .	-700
# Supporting Research and Testing - Funding increase supports additional field test costs for Next Generation Turbine project.	1,400
Total Funding Change, Turbine Research.	2,000
Cooperative Research and Testing	
# Wind Powering America - Supports major new national initiative with funding for regional programs and partnership development, regional analyses, wind mapping, expanded Federal activities, and an educational program.	5,000
# Industry Support - Decrease reflects shift of outreach activities from Industry Support to Wind Powering America.	-181
# Regional Field Verification - Activity transferred from Turbine Research, and planned to support 3-5 new central station and distributed field verification projects, and associated laboratory in-house support costs.	5,000
# International Clean Energy Initiative - Anticipated first year costs for 2-3 distributed wind power analysis projects and 2-3 hybrid systems field verification projects.	4,000
# Utility Analysis - Funding increase to support startup of the Wind Performance Monitoring Network.	700
Total Funding Change, Cooperative Research and Testing.	14,519
Total Funding Change, Wind Energy Systems.	18,019

Renewable Energy Production Incentive

Mission Supporting Goals and Objectives

Program Mission

The mission of the Renewable Energy Production Incentive (REPI) is to encourage the acquisition of renewable energy generation systems by state and local governmental entities and non-profit electric cooperatives. For these tax-exempt owners of new renewable energy generation systems, REPI provides financial incentives that are comparable to the value of either production tax incentives or investment tax credits that are available to the private-sector owners of certain types of new renewable energy generation systems. For comparability, new renewable energy generation systems that use solar, wind, geothermal, or closed-loop biomass technologies receive priority for REPI payments over systems that use allowable open-loop biomass technologies. Each qualified facility, first operated in the fiscal year 1994-2003 time frame, is eligible for incentive payments for the net electricity produced during the first 10 fiscal years of its operation, subject to the availability of annual appropriations.

Program Goals and Objectives

A major goal in the annual budget request for REPI is to provide financial incentives for public entities that acquire new renewable energy generation facilities that are comparable to the tax incentives that are available to the private sector. In order to accomplish this goal and to maintain a balanced portfolio for the Solar and Renewable Energy account, full incentive payment funding is planned for all new qualified facilities that use solar, wind, geothermal, and closed-loop biomass technologies. A lesser level of payments is planned for new qualified facilities that use open-loop biomass technologies.

Strategic Approach

Both the Department's Strategic Plan and the Comprehensive National Energy Strategy have a goal of significantly increasing the non-hydroelectric renewable energy generating capacity by 2010 to at least 25,000 megawatts. The portfolio of renewable energy research and development programs is improving the performance and reducing the cost of these technologies. However, temporary government support, as envisioned in the report of the President's Council of Advisors on Science and Technology, is needed to facilitate the demonstration and use of these technologies. REPI provides this temporary financial support to the non-Federal public sector. This financial support is comparable to the value of tax incentives that are being provided to the private sector for the near-term acquisition and operation of solar, wind, geothermal, and closed-loop biomass generation systems.

Program Benefits

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.03	0.03	0.03
Energy Savings (\$ Billions)	0.07	0.07	0.07
Carbon Displaced (MMTCE)	13.8	13.8	13.8

Performance Measures

- # FY 1999 appropriations provided incentive payments for qualified facilities that generated approximately 529 million kilowatt-hours in fiscal year 1998.
- # It is anticipated that REPI will annually facilitate the addition of new qualified facilities to the program through fiscal year 2003 with these facilities producing almost one billion kilowatt-hours of electricity in fiscal year 2004.

Significant Accomplishments and Program Shifts

FY 1999, FY 2000, and FY 2001 appropriations will be sufficient to make production incentive payments for all of the electricity generated by qualified facilities which use solar, wind, geothermal, or closed-loop biomass technologies. Only a portion of the electricity produced by qualified facilities which used open-loop biomass technologies will receive incentive payments, determined by the availability of remaining appropriated funds.

Program Completion

The last fiscal year of electric production that is eligible for payments under this program is FY 2012. Therefore, production incentive payments using FY 2013 appropriations, if provided, will be the final planned activity for this program.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Renewable Energy Production Incentive	4,000	1,500	4,000	2,500	166.7%
Total, Renewable Energy Production Incentive ...	4,000	1,500	4,000	2,500	166.7%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Annual Production Incentive Payments

#	Payments will be provided to the owners of approximately 45 to 50 qualified facilities at the rate of about \$0.017/kWh. Make full production incentive payments for all the electricity produced by qualified facilities that use solar, wind, geothermal, or closed-loop biomass technologies. This provides comparability to tax incentives provided to private sector owners of similar systems. The increase provides a higher amount of incentive payments to owners of facilities that use open-loop biomass technologies.		
	4,000	1,500	4,000
Total, Renewable Energy Production Incentive	4,000	1,500	4,000

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

Renewable Energy Production Incentive

#	The increase provides a higher proportion of payments to open-loop biomass, particularly landfill gas facilities that qualify for the incentive. Landfill gas projects offer a relatively low cost near term opportunity for greenhouse gas reductions, while also addressing local pollution concerns	
		2,500
Total Funding Change, Renewable Energy Production Incentive.		2,500

Solar Program Support

Mission Supporting Goals and Objectives

Program Mission

Electricity Restructuring - The mission of the Electricity Restructuring program is to provide unbiased technical assessments to Federal and State officials of utility restructuring issues relating to renewable energy and energy efficiency. The assessments will help decision makers at the Federal and State levels both develop and coordinate utility restructuring regulations and legislation to ensure suitable policy and market mechanisms for renewable energy and energy efficiency. These assessments will identify utility restructuring concepts that will also have transferability in the evolving electric markets of other countries; thereby, facilitating the increased use of advanced U.S. energy technologies developed under the Department's RD&D programs.

Competitive Solicitation - The mission of this program is to obtain, analyze, and disseminate essential cost and operational information. This activity is necessary for the R&D community, renewable industry and the financial community to overcome the perceptions of risk in selecting renewable energy and hybrid renewable energy generation/cogeneration systems for use in the competitive electric market.

Program Goals and Objectives

Electricity Restructuring - The goal of Solar Program Support is to assist State, regional, and Federal agencies in developing utility restructuring concepts for energy efficiency and renewable energy technologies and programs. A key objective is to assess the costs and benefits of renewable portfolio standards, public benefits funds, consumer information and disclosure provisions, green marketing programs, distributed generation concepts, and other policy and market mechanisms for energy efficiency and renewable energy technologies in restructured utility markets. Another objective is to provide unbiased information and materials to State, regional, and Federal decision makers on the potential impacts on electricity markets from restructuring. Also, to assist in the coordination of Federal, regional, and State agencies in the implementation of utility restructuring legislation and regulation for energy efficiency and renewable energy technologies and programs following enactment of Federal legislation. Key utility restructuring concepts for the U.S. electric market can also be applied to the evolving electric markets in other countries. The successful transfer of these concepts have an additional benefit to the Nation of increasing the use of advanced U.S. energy technologies developed under the Department's RD&D programs.

Competitive Solicitation - This effort supercedes activities formerly included within the Federal Buildings/Remote Power Initiative. Through a technology-focused and competitive process, this effort will carry out targeted field validation and education efforts that: 1) prove the availability of clean, affordable, and reliable electric power supply options for many remote and/or economically challenged regions of the nation and at Federal facilities, on Native American lands or Tribal Colleges; 2) obtain essential data on operational performance, reliability, and benefits of renewable energy and hybrid

renewable energy generation/cogeneration systems in various geographic locations and climatic conditions; or 3) enhance the understanding or application of renewable energy technologies.

The objectives from this effort will be to make information resulting from these validation efforts available, in easy-to-understand format, to decision makers considering additional or replacement power generation systems or to instructors for educational or practical training; and substantially contribute to the achievement of tripling renewable energy generation capacity (non-hydroelectric) in the U.S. by 2010, consistent with both the Department's Strategic Plan and the Comprehensive National Energy Strategy.

Strategic Approach

Electricity Restructuring - The Electricity Restructuring Program seeks to enable a smooth transition to more open and competitive markets for electricity energy services in the U.S. such that consumers and the Nation can realize the benefits of competition (e.g., lower prices, better service, more choices) in a manner that also assures the advancement of important public goals in such areas as renewable energy and energy efficiency, low income assistance, and public interest research and development. This is accomplished through technical analysis and assistance to key state energy and environmental officials on policy and restructuring technical issues.

The program accomplishes this mission by sponsoring technical analysis and outreach to disseminate findings quickly and cost effectively. The program establishes partnerships with State, regional, and national organizations that have roles in utility restructuring legislation and regulation.

The program is critical to the future of energy efficiency and renewable energy technologies in restructured electricity markets. Federal electricity restructuring legislation is pending. Some States have implemented electricity restructuring legislation and/or regulations, others have not. There is no national effort, other than this program, aimed at achieving better Federal-State coordination on electricity restructuring and energy efficiency and renewable energy technologies and programs.

For the International Clean Energy Initiative, additional analyses will be conducted on the transferability of utility restructuring concepts from the U.S. electric market to the evolving electric markets of other countries. The adoption of these utility restructuring concepts in these countries will facilitate the increased use of advanced U.S. energy technologies, thereby increasing the economic benefits to the Nation from its investment in the Department's RD&D programs.

Competitive Solicitation - Competition resulting from the restructuring of the electric utility industry will favor the selection of systems with low first costs over systems with higher first costs, but comparable or lower life-cycle costs. From a risk perspective, energy providers will also select advanced generation technologies that have evolved from familiar fossil-fuel technologies, which have had long service lives and high levels of reliability and scheduled availability. Emerging generation technologies, such as renewable energy, are at a market selection disadvantage due to the lack of comparable cost and operational information. This multi-year program is directed at obtaining vital cost, operational information and practical educational curricula for a wide variety of systems in various sectors (including Federal facilities and Native American lands and Tribal College localities) and various geographic regions. By 2004, the program will have completed planned funding of cost-shared field verification projects for renewable energy and hybrid renewable energy generation/cogeneration systems. Hybrid systems could

include combinations of renewable energy generation technologies, integrated renewable energy/energy storage systems, and integrated systems utilizing renewable energy and fossil fuels (such as natural gas or coal).

The portfolio of renewable energy research and development programs is improving the performance and reducing the cost of these technologies. However, reports such as that by the President’s Council of Advisors on Science and Technology indicate that R&D alone is not sufficient to launch new technologies in the market. Among the substantial market barriers discussed in this report are the perceptions of risk with new emerging technologies, such as renewable energy generation. To address these perceptions of risk, this program funds a spectrum of cost-shared field verification projects in various geographic regions to obtain the needed cost and operational information for these renewable energy systems.

The program is composed of three competitive components: systems or educational undertakings benefitting Native Americans or Tribal Colleges, systems located at remote Federal facilities, and systems that would be selected to assist residents of remote areas in a more general portion of the solicitation.

For systems benefitting Native Americans, the cost-sharing of 20 percent or greater per DOE dollar of funding would be encouraged. The proposed projects will be administered through a competitive financial assistance process. In order to ensure a viable pool of projects over the time frame of this program, a portion of the funding for these categories in FY 2001 will be used for cost-shared feasibility studies. These studies will address the economics, needed licenses and permits, and potential environmental issues for proposed field verification projects.

Assuming level funding over the six-year life of the Competitive Solicitation program, up to 200 field verification projects utilizing renewable energy will be installed in various locations across the Nation (the actual number of projects depends upon the size and cost of projects selected from the annual competitions). These projects will provide power to 1,000 remote homes and tribal buildings by 2008 and provide energy savings of \$4,500,000 in avoided fossil fuel costs.

Program Benefits

Metrics	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.00	0.00
Energy Savings (\$ Billions)	0.00	0.00	0.01
Carbon Displaced (MMTCE)	0.01	0.06	0.05

Although the primary purpose of this program is field verification of various power generation systems that utilize renewable energy technologies, the impact upon the lives of those receiving the electricity from these systems or educational benefits is not insignificant. In fact, once all the projects are completed these systems will produce the amount of electricity needed to power more than 22,500 homes across the Nation.

Performance Measures

FY 2001 Performance Measures

Electricity Restructuring

- # Increased consistency between State and proposed Federal legislation in the key parameters for renewable portfolio standards, public benefits funds, net metering programs, and consumer information and disclosure provisions.
- # For the International Clean Energy Initiative, two-to-three week tailored training programs will be conducted for state electric utility regulators, natural gas sector regulators and statistical agencies. Approximately 30 programs will be conducted, directed at 10 countries targeting relevant agencies in the three areas (electricity, natural gas and social costs).
- # Development of at least two regional market strategies, indexes, for energy efficiency technology deployment and effectiveness measurement techniques for use by States in their restructuring legislation and regulations.
- # Specific utility restructuring concepts identified that can be successfully transferred to the evolving electric markets of other countries, will be performed for the International Clean Energy Initiative.

Competitive Solicitation

- # Competitively award 3-20 field validation educational projects to reduce the perception of risk in using renewable technologies in remote grid-connected and off-grid applications. Projects success will be determined by acceptance of renewable energy technologies as a viable primary or supplemental energy source.

FY 2002 - 2006 Performance Measures

Electricity Restructuring

- # Increased number of information publications, materials, industry web site access, conference presentation over FY 2001.
- # Development of two additional regional market strategies for energy efficiency technology deployment.
- # Legislation enacted by all States consistent with proposed Federal electricity restructuring legislation requirements for public benefits.
- # Additional market opportunities for advanced U.S. energy technologies exploited due to the successful transfer of U.S. utility restructuring concepts.

Competitive Solicitation

- # The six year program will result in at least 50-100 cost-shared field verifications of renewable energy and renewable energy hybrid generation/cogeneration systems of various system configurations for various geographic remote regions, at remote Federal facilities, and on Native American lands or Tribal Colleges.
- # 1,000 remote homes and tribal buildings will be powered by renewable or hybrid systems collectively providing 1-5 MW of power.
- # The direct savings of the systems should be approximately \$4,500,000 annually in energy costs. Indirect savings will be substantially higher; the cost and operational information from these systems will address the market perceptions of risk in the selection of these systems and thereby facilitate the selection of similar systems.

Significant Accomplishments and Program Shifts

FY 2000 Planned Accomplishments

Electricity Restructuring

- # Five to ten reports will be completed on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.
- # Technical assistance on electricity restructuring issues will be provided to approximately ten States, individually.
- # Technical assistance to State organizations on electricity restructuring issues.

Competitive Solicitation

- # Five to ten cost-shared feasibility studies will be undertaken in conjunction with Native American Tribal Colleges.

Distributed Power

- # Initiated five to ten cost-shared Distributed Power systems integration R&D projects.

FY 2001 Planned Accomplishments

Electricity Restructuring

- # Five to ten reports will be completed on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.
- # Two regional workshops will be completed on electricity restructuring issues.
- # Technical assistance on electricity restructuring issues will be provided to approximately 10 States, individually, on an as-required basis.
- # Technical assistance will be provided to State organizations on electricity restructuring issues.

- # Complete assessments on the transferability of utility restructuring concepts to countries that have evolving electric markets, for the International Clean Energy Initiative.
- # The International Clean Energy Initiative will provide support for the measurement and analysis of the social costs of energy production, transportation, and consumption, and for the social costs of rural electrification programs in particular.
- # The International Clean Energy Initiative will provide state utility regulators with tailored, on the job training with U.S. private sector utilities and state electric utility commissions.

Competitive Solicitation

- # Competitively award approximately 8-15 field validation projects or educational undertakings and initiate development of same. Selected projects will reflect a range of technology applications and a diversity of geographic locations and climate conditions.

FY 2002 - 2004 Planned Accomplishments

Electricity Restructuring

- # Reports on the impacts and implementation policies of State restructuring legislation and regulations on renewable and energy efficiency technologies.
- # Conduct two regional workshops on electricity restructuring issues.
- # Technical assistance on electricity restructuring issues provided to States, individually.
- # Technical assistance to State organizations on electricity restructuring issues.
- # Complete evaluation and documentation of the successful transfer of utility restructuring concepts to evolving electric markets of other countries and its resultant benefits.

Competitive Solicitation

- # A sufficient range of 50-100 highly leveraged (a minimum of 50% cost-share is required except in the Native American component which requires 20%), competitively-awarded projects would be funded under this program. Projects would be selected based upon criteria ensuring technology and configuration variety, high value of data to be received, and geographic/climate diversity.

Program Completion

Electricity Restructuring

The Electricity Restructuring program will be completed by FY 2005, as all States implement their individual and Federal restructuring requirements.

Competitive Solicitation

Assuming level funding over the planned six-year lifetime of this program, final cost-shared project awards will be made by FY 2005. Projects initiated in FY 2005 should be completed by the end of FY 2006. Data on operational performance, system reliability, and other essential project information is required from each project once its operation begins so that this information can be consolidated and

shared with decision makers considering the use of renewable or hybrid renewable power when they are faced with adding new or replacing existing power supplies. The comparatively small, but vital, project information collection component of this effort is projected to continue until approximately FY 2009 - FY 2010, at which time the entire program will conclude.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
Electricity Restructuring					
Technical Analysis & Technical Assistance	0	984	1,000	16	1.6%
International Clean Energy Initiative	0	0	1,500	1,500	>999%
Subtotal, Electricity Restructuring	0	984	2,500	1,516	154.1%
Competitive Solicitation					
Feasibility Studies	0	1,000	0	-1,000	-100.0%
Projects	0	0	4,000	4,000	>999%
Distributed Power	0	2,952	0	-2,952	-100.0%
Subtotal, Competitive Solicitation	0	3,952	4,000	48	1.2%
Total, Solar Program Support	0	4,936	6,500	1,564	31.7%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Electricity Restructuring

Technical Analysis and Assistance - Electricity restructuring information and analyses will be disseminated to State and regional electricity agencies, power suppliers, energy service companies, and other market participants in competitive electric markets. The information will focus on issues affecting energy efficiency and renewable energy technologies, including exploration of what has worked in one region or state to assist other states in development of their policies or restructuring. Publications, presentations, web site development will be used to disseminate these "lessons learned."

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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Specific analytic activities include analysis of policy mechanisms such as information disclosure provisions, renewable portfolio standards and public benefits funds. Analysis of future utility and regulatory systems such as distributed power, bid-based pools, real-time pricing, market power, and transmission access and pricing issues, will be performed. Analysis of market mechanisms such as labeling of electricity products for consumers, “green” certification, and energy services strategies will also be completed. Technical assistance will be provided to support regional State, and Federal decision makers in the electricity restructuring process. The funds will support regional networks, seminars, workshops, information dissemination mechanisms such as web sites, in order to inform decision makers on electric restructuring and the role of energy efficiency and renewable energy technologies. These activities will ensure that State have the most recent, accurate, and unbiased information available on electric restructuring and the impacts on renewable and energy efficiency technologies.

The funding level will provide technical analysis and assistance activities given the expected number of States (approximately 35) that will be implementing electricity restructuring activities in FY 2001. The level of funds will provide funds for most State organizations for technical assistance to meet many of the informational and technical analytic needs of State decision makers.

0	984	1,000
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International Clean Energy Initiative - Regulatory Reform

Technical Assistance - Analyses of the impacts and opportunities for reform of energy sectors at national and sub-national levels will be conducted in consultation with experts from the Department’s Policy Office and participants in developing and transitioning countries. Technical reports, conferences, workshops, and other communication mechanisms will be used to transmit the information from the analyses to as wide an audience as possible. Support will be provided for the measurement and analyses of the social costs of energy production, transportation, and consumption, and for the social costs of rural electrification programs. Regional networking activities will be developed that

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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include existing regulatory authorities as well as newly-established regulatory agencies from Central and Eastern Europe and the Newly Independent States. Lessons learned from the U.S. energy market reform, which has been occurring in the natural gas industry and now beginning in the electricity market, will be examined for use by developing/transition countries.

0	0	1,500
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Total, Electricity Restructuring.

0	984	2,500
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Competitive Solicitation

Feasibility Studies - Cost-shared feasibility studies ensuring a viable pool of field verification projects for Native Americans will completed in FY 2000. These funds enable the competitive selection of cost-shared feasibility studies which will provide a pool of viable field verification projects beginning in FY 2001 through the life of the program.

0	1,000	0
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Projects - Undertake cost-shared projects to obtain needed cost and operational information. A sufficient range of 50-100 highly leveraged (a minimum 50% cost-share is required except for the Native American component which is 20%), competitively-awarded projects would be funded over the lifetime of this program.

Use financial incentives with the Federal agencies to leverage installed cost-effective projects. Provide technical assistance to build infrastructure for future purchases of solar energy. Identify and fund 8-15 leveraged remote applications of solar and renewable energy to reduce or avoid diesel and gasoline power generation. In 2001, projects (approximately 8-15) would be selected based upon criteria ensuring technology and configuration variety, high value of data to be derived, and geographic/climate diversity. Both off-grid and grid-connected projects will be selected. Such a diverse array of projects operating under a range of conditions is essential in order to obtain the hard performance data required by potential decision makers, investors and financial institutions and to reduce the perceptions of risk surrounding the development of power generation facilities that utilize renewable energy technologies. The funding levels requested below were

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
established through experience-based estimates of the range of possible projects and required cost-share levels and are consistent with program goals and objectives.	0	0	4,000
# Distributed Power - Conduct distributed power system integration research and development to include modeling, field testing and analyses to determine the test means of integrating distributed power resources, including renewable energy, combined heat and power, and hybrid systems into the electricity system in a manner that enhances reliability, safety and power quality. Funding for FY 2001 is requested under Electric Energy Systems and Storage Transmission Reliability.	0	2,952	0
Total, Competitive Solicitation.	0	3,952	4,000
Total, Solar Program Support.	0	4,936	6,500

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs.
FY 2000
(\$000)

Electricity Restructuring

# Technical Analysis and Assistance - The increase provides sufficient funding for the competitive solicitation, which provides financial assistance of state organizations involved in state electricity restructuring.	16
# International Clean Energy Initiative - Regulatory Reform Technical Assistance - This increase will allow credible analysis of key utility restructuring concepts in the United States and their successful transfer to evolving electric markets in other countries. This successful transfer will facilitate the increased use of advanced U.S. energy technologies in these countries, thereby providing additional economic benefits to the Nation from its investments in the Department's R&D programs.	1,500

Competitive Solicitation

# Feasibility Studies - Cost-shared feasibility studies will be completed in FY 2000.	-1,000
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FY 2001 vs. FY 2000 (\$000)

# Projects - An increase of 8-15 cost-shared projects, both off-grid and grid-connected projects, will be selected. Based on criteria ensuring technology and configuration variety, high value of data to be derived, and geographical climate diversity.		4,000
# Distributed Power - Distributed Power systems integration research and development funding is being requested under Electric Energy Systems and Storage, Transmission Reliability.		-2,952
Total, Funding Change, Solar Program Support.		<u>1,564</u>

National Renewable Energy Laboratory

Mission Supporting Goals and Objectives

This activity supports the National Renewable Energy Laboratory (NREL) infrastructure which includes the necessary repairs, maintenance, upgrades, new construction and facility modifications to protect the Federal Government's investment and ensure that the NREL remains the Nation's exemplar center for Research and Development (R&D) of Energy Efficiency and Renewable Energy technologies.

NREL's predecessor was established in 1977 as the Solar Energy Research Institute (SERI) and was rededicated as the newest of the National Laboratories in 1996. As a "single purpose" laboratory, the NREL specializes in Energy Efficiency and Renewable Energy technologies which makes it unique to the DOE National Federal Laboratory complex. The laboratory is located on four sites near Golden, Colorado, and is comprised of approximately 100 laboratories contained in 605,796 square feet devoted to laboratory operations. The NREL's first permanent research facility, the Field Test Laboratory Building (FTLB), was completed in 1984 and other facilities were added in subsequent years.

Today, NREL supports the mission requirements for a broad segment of the Energy Efficiency and Renewable Energy Programs. Major facilities include the Solar Energy Research Facility (SERF) which houses laboratories that conduct a broad array of R&D ranging from photovoltaic, superconductivity, and advanced materials science; the FTLB which houses laboratories for R&D in alternative fuels and industrial processes; the Alternative Fuels User Facility (AFUF) which focuses on ethanol, methanol, and other alternative fuels; the Outdoor Test Facility for analyzing photovoltaic devices; the Thermal Test Facility for testing active and passive solar systems; and the High-Flux Solar Furnace (HFSF) for work on high-temperature R&D in ceramics and other applications. Additionally, major laboratories are located at the National Wind Technology Center (NWTC) for testing of wind power systems.

One of NREL's principal goals is to maintain its core competencies which are world renowned in Advanced Materials and Prototype Component Development; Development and Characterization of Renewable Energy, Energy Efficiency, and Waste Conversion Processes; Systems and Process Engineering and Integration for Renewable Energy and Energy Efficiency; and Establishing Partnerships for Market and Technology Development for Renewables and Energy Efficiency.



Aerial view of the National Renewable Energy Laboratory, Golden, Colorado

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	\$ Change	% Change
General Plant Projects (GPP)	1,869	750	400	-350	-46.7%
General Purpose Equipment (GPE)	2,031	350	1,500	1,150	328.6%
Total, National Renewable Energy Laboratory.	3,900	1,100	1,900	800	72.7%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001
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General Plant Projects (GPP) Funding

Infrastructure Renovations/Upgrades - Infrastructure renovations and upgrades at the NREL South Table Mountain (STM), and National Wind Technology Center (NWTC) sites. Work includes minor site modifications, patching, repair, and retopping of deteriorating roads and parking lots, safety fencing, landscaping improvements, building metering, repair and replacement of leaky roofs. Completed the installation of a 2,000 sq. ft. multi-user prefabricated facility for solar radiation research to replace dysfunctional shipping and storage containers currently being used. The FY 2001 request will support two of the most critical projects: (a) the installation of fire detection (smoke and heat detection) and alarm system upgrades in the Field Test Laboratory Building (FTLB) to bring the Laboratory up to current NREL safety standards for laboratory buildings; and, (b) expand the capabilities of the Site Entry Building at the South Table Mountain Site (STM) to provide the space required to meet NREL's requirements for emergency, access control, personnel, and facility management. The decrease for GPP reflects a higher prioritization in FY 2001 on the purchase of general purpose equipment.

	1,869	750	400
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General Purpose Equipment (GPE)

Data Systems, NREL General - GPE activities to support the GPP project of the installation of data system infrastructure upgrades. Work includes the procurement and installation of

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
critical Y2K compliance items such as upgraded telecommunications equipment and conversion of existing Novell software and hardware network to Microsoft Windows NT, upgrading the computer network backbone and the Wide Area Network, purchasing uninterruptable power supplies, and a Data Warehouse server	2,031	0	0
# GPE - This provides for the updating, upgrading, or replacement of existing equipment and systems that are the underpinning of the research and development at the NREL laboratories. This funding supports equipment and systems that are worn out, no longer economically maintainable, no longer in production, or obsolete due to technological advances. Critical multi-program equipment which has reached its serviceable life-span includes laboratory standards and calibration equipment, toxic gas monitors, and a liquid chromatograph-mass spectrometer. The increase in FY 2001 supports: (a) scientific, multi-program, laboratory equipment; and, (b) computer, telecommunications, and networking systems. The scientific equipment includes a 900MHz Nuclear Magnetic Resonance Spectrometer which will greatly enhance NREL's research core competencies in material characterizations and will support research across the Laboratory for work that includes organic compounds that are important in energy conversion processes; biomolecules and polypeptides in biotechnology research for fuels and chemicals, and electronic materials in photovoltaic research. Also, the request will provide for a pyranometer calibration system to support heat transfer measurements. The computer/telecommunications equipment includes information technology system upgrades and replacements to maintain the NREL's scientific data processing and transfer requirements to support the research programs. Funding is also included for emergency repairs and replacements to maintain the operational capability of the Laboratory's aging existing systems.	0	350	1,500
Total, General Purpose Equipment (GPE)	2,031	350	1,500
Total, GPP and GPE.	3,900	1,100	1,900
Total, National Renewable Energy Laboratory.	3,900	1,100	1,900

Explanation of Funding Changes from FY 2000 to FY 2001

FY 2001 vs. FY 2000 (\$000)

General Plant Projects (GPP)

# Reflects a reduced level of GPP in FY 2001 in order to support higher priority general purpose equipment.	-350
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General Purpose Equipment (GPE)

# An increase of \$950,000 is needed primarily for the purchase of a 900MHz Nuclear Magnetic Resonance Spectrometer and \$200,000 to support the information technology system upgrades to provide for scientific and business data storage, retrieval, and transmission.	1,150
Total Funding Change, National Renewable Energy Laboratory	<u>800</u>